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THE TOP RIGGING OF A BLAST FURNACE, SHOWING A SKIP CAR READY TO DUMP INTO THE UPPER BELL.

ELECTRICAL MACHINERY IN STEEL MAKING.—[SEE PAGE 231.]

WOOD DISTILLATION.*

A DISCUSSION OF METHODS.

BY W. C. GEER.

THERE are two distinct processes for obtaining valuable products from wood by distillation—destructive distillation and steam distillation. In the destructive process the wood fiber is broken down and new compounds are formed, but in the steam process this is not properly the case. In both processes the volatile compounds of the wood are vaporized.

In the destructive distillation heat is applied below the wood-containing vessel, which has a comparatively small pipe as its only outlet. The heat vaporizes the volatile compounds, such as water and turpentine, and breaks down the non-volatile compounds, such as cellulose and the wood gums; it forms a number of new compounds, usually of a simpler chemical nature, and these in turn are vaporized with the water and turpentine, leaving a residue of charcoal. The decomposition of the wood in this process is exceedingly complicated and is not yet fully understood.

In steam distillation, which is much simpler, the wood is chipped and placed in a closed receptacle into which steam is blown from a boiler, and the volatile compounds which are not chemically united with the rest are vaporized and carried out of the retort with the steam. Though in practice the wood is often so much overheated that the wood fiber is slightly decomposed, and though it is quite possible to carry the overheating so far that the process becomes one of destructive distillation, it is nevertheless true that "steam distillation," as the term is technically used, signifies the separation of volatile products from wood with, at most, but little decomposition of the wood fiber.

With both these processes the vaporized compounds, after leaving the retort, pass through water-cooled tubes, where they are condensed into the crude liquors, which, after refining, yield marketable products.

Different woods give different marketable products after distillation. Thus, the hardwoods—beech, birch, and maple—yield acetate of lime, wood alcohol, and charcoal, and long-leaf pine yields turpentine, tar, pine oils, and charcoal. This difference in the products is due to the fact that pine woods are resinous, while hardwoods are non-resinous. From the point of view of products, therefore, it is necessary to distinguish between the kinds of wood used, as well as between the distillation processes.

DESTRUCTIVE DISTILLATION OF HARDWOOD.

Hardwood distillation has been an established industry in the United States for a number of years. The products already mentioned are wood alcohol, charcoal, and acetate of lime, each of which has important uses. The plants are located in the northern part of the United States, where, except for the Appalachian hardwood belt, the hardwoods are most common.

The woods used are largely beech, birch, and maple, with the last preferred. The wood is cut into cord-wood lengths and allowed to season for a year. According to the best information, the amount of the products obtained from green wood and from ordinary dry wood is not different, cord for cord, but the higher water content of green wood dilutes the distillate and necessitates more fuel for the carbonization. Excessive seasoning will doubtless reduce the yield of valuable constituents. Body wood is better than slab wood. Very small wood, such as thin edgings, carbonizes so rapidly that it must be mixed with larger pieces. The problem of the destructive distillation of sawdust has not yet been satisfactorily solved.

Apparatus.—Wood is heated or carbonized in three forms of apparatus: (*a*) In brick kilns, (*b*) in retorts, (*c*) in ovens.

The charring of wood is a process as old as civilization. In the early days the wood was charred under sod in the old charcoal kiln, which has been a familiar sight over a good part of the world. The modern charcoal kiln is so made that valuable vapors are condensed from the smoke, which in the old-fashioned kiln escaped into the air and were wasted. Kilns are now mainly used to produce charcoal for blast furnaces for pig iron. They are made of brick, with a circular base, and divided approximately into two semi-circular sections. They hold each about fifty cords, and are charged and discharged by hand. The vapors are carried off into condensers, where the condensible ones are liquefied.

The name "retort" is given to a small form of cylindrical vessel holding about three-fourths of a cord. The retorts are set horizontally in brickwork, in pairs, each pair forming a "battery," and heated from beneath. They are filled and discharged from a single door in front, which can be tightly fastened. The top of the battery is often tiled and serves as a drying floor for acetate of lime. The condensers are of copper and are cooled by water. A "run," from charging to recharging, takes twenty-four hours.

The invention of the "oven" form of carbonizing vessel marked a distinct forward step in wood distillation. Oven kilns are made large enough to hold from two to four cars, which are run in on tracks, each loaded with about two cords of wood. They are usually fired separately, and the vapors pass over into the condensers, either at the side or at the end. In other respects they resemble the "retorts."

Products.—Four crude products are obtained from each of these forms of carbonizing vessel: (1) Charcoal; (2) a non-condensible gas, which is carried off by suitable pipes; (3) an aqueous liquor known as "pyroligneous acid"; and (4) wood tar, which is condensed with the pyroligneous acid.

The charcoal is cooled differently in the case of each distilling vessel though in all cases it is cooled for forty-eight hours. With kilns, it is allowed to cool before being removed; with the retorts, it is shoveled into drums or cans and sealed from the air; and with the ovens, the loaded cars are run out and inclosed in large coolers, which are similar in form to the ovens.

The gas from the kilns is piped back into the kiln furnaces, where it serves to carbonize the wood. The gas from retorts and ovens is burned under the boilers or under the retorts.

The pyroligneous acid and the tar run off together from the condensers into vats, where the tar settles. The pyroligneous acid is reddish-brown in color and has a strong, characteristic burnt-wood odor. The tar, when in thin layers, is dark brown in color, and has a bad odor. These two liquid products are refined by processes which in general are the same for each of the three forms of carbonizing apparatus. The processes differ somewhat, however, at the different plants.

Dissolved in the tar are some of the valuable compounds of the pyroligneous acid, while dissolved in the pyroligneous acid are some tarry bodies. Both liquids are distilled in order to concentrate the valuable substances, which are chiefly acetic acid and methyl or wood alcohol. The concentrated liquid containing the acetic acid and methyl alcohol is neutralized with lime and distilled from a "lime-lee" still, giving, (1) a residue which, upon evaporation, yields gray acetate of lime, and (2) a distillate which, upon refining, yields the various grades of wood alcohol.

Some plants obtain a crude, brown, evil-smelling wood alcohol, of 82 per cent strength, which is sent to a refinery for further treatment; others obtain a 95 to 99 per cent product without color or unpleasant odor. Wood alcohol is ill-smelling only when impure as a result of incomplete refining.

Oven and retort plants which produce alcohol no purer than 82 per cent secure about the following average yields from wood distillation per cord of wood:

Charcoal	45 to 52 bushels.
Gray acetate of lime	180 to 225 pounds.
Wood alcohol, 82 per cent	8 to 10 gallons.

The lack of chemical supervision at the works makes statements of yield a little confusing, since wood alcohol and acetate of lime are variable in quality, and the number of gallons and pounds may therefore actually represent products of quite different composition.

Kiln plants obtain about the following yield per cord of wood:

Charcoal	45 to 52 bushels.
Acetate of lime	90 to 150 pounds.
Wood alcohol, 82 per cent	4 to 6 gallons.

Use of Products.—These compounds have a variety of uses, which may be briefly mentioned. Charcoal is used in blast furnaces for the production of pig iron, in copper and sugar refineries, in the production of gunpowder, for fuel, etc. Wood alcohol is sold under a variety of trade names, such as "columbian spirit" and "colonial spirit." It is most widely used as a solvent in the production of shellacs and varnishes. It is also used in hatmaking, in perfumery, in the coal-tar dye industry, in manufacture of formaldehyde, and for mixing with grain alcohol to produce "denatured" or "industrial" alcohol. The acetate of lime is a gray, finely crystalline body, which is used in the manufacture of wood vinegar, acetic acid, many commercial acetates, acetic ether, acetone, and other products. (From the acetone may be produced iodoform and chloroform.)

A number of receipts for the preparation of denatured alcohol have been recently authorized by Congress and established by the Commissioner of Internal Revenue, so that denatured alcohol, with its due admixture of wood alcohol, is now a market article. The wood distillation plants now in existence in the United States are able to produce probably 30,000,000 gallons of wood alcohol annually.

Denatured alcohol is now a competitor of wood alcohol. At present the producers and refiners of wood alcohol are in suspense as regards the extent of the consumption of the product for denaturing purposes.

STEAM DISTILLATION OF HARDWOOD.

Several species of hardwood are distilled by steam in order to obtain valuable essential oils. Sweet birch, for example, yields "oil of wintergreen," an oil used in medicinal preparations. No thorough study has yet been made of this division of the subject, but it is known that a small industry is supported.

DESTRUCTIVE DISTILLATION OF YELLOW PINE.

The destructive distillation of yellow pine is carried on in the Southern States, where the distillation plants are so widely scattered that a statement of the location by States would mean but little.

The wood generally used is that of long-leaf pine, from which turpentine and rosin are mainly obtained. At some plants, however, long-leaf pine, short-leaf pine, Cuban pine, and others are indiscriminately used, but for the best results long-leaf and Cuban pines are selected. The most valuable material is wood rich in resinous contents, or "fat," in which lightwood and stumps rank first, wood immediately under the "box faces" next, and slabs and other mill refuse last. Pine sawdust is not used for destructive distillation.

Apparatus.—Iron or steel retorts are used, varying in capacity from one to four cords. They are either vertical or horizontal. The vertical retorts have their long axis upright, and are set singly in brickwork with suitable flues, usually with the openings for charging and discharging at the top and bottom. The firebox below is at one side, so that the heat goes around the outside of the retort itself. Few of these retorts are now in use.

The horizontal retorts are similar to those used in hardwood distillation. Though they differ as to form, all are cylindrical steel vessels set in batteries in brickwork, and are charged and discharged through doors at one or both ends. The gases escape through pipes to copper condensers. The firebox is sometimes constructed to fire two retorts at a time, though usually but one.

Products.—Though there are a number of methods which differ somewhat in results, the five products usually obtained are: (1) Charcoal; (2) a non-condensible gas; (3) light oils, which are often taken in two fractions, one of which is a crude turpentine; (4) tar, and (5) pyroligneous acid. At some plants the light oil vapor, which volatilizes easily, is led off into condensers with the gas and pyroligneous acid, while the tar, which is heavier, is drawn off at the bottom; at others, the entire volatile product is driven off through a pipe at the top, and, after passing through the condenser, is separated into the crude turpentine and tar fractions.

There is no more uniformity in heating methods than in the form of the retorts. The run is thirty-six or forty-eight hours, or longer.

Charcoal which is to be sold is cooled in the retort, and that which is to be used for fuel is drawn hot and sprayed with water to prevent fire. The gas is allowed to run to waste or is burned under the retorts and boilers.

The pyroligneous acid from hardwoods contains the most valuable products, but that from pine, which has a strong odor and a reddish-brown color, is of such different composition that very little is done with it. The yield from a cord of pine wood is, according to the most widely accepted figures, not more than three gallons of 82 per cent wood alcohol and about 70 pounds of brown acetate of lime. The extraction of wood alcohol from pine wood is not at present on a commercial basis, and at the majority of plants the pyroligneous acid runs to waste.

The crude turpentine is a dark red oil with the bad odor associated with products of destructive distillation. After proper fractional distillation, it yields for market a nearly colorless turpentine which has a distinctive odor.

The tar is sometimes refined far enough to produce a good quality of retort tar and to yield oils which, with the heavy distillates from the crude turpentine,

* From Forest Service Circular 114, United States Department of Agriculture.

make disinfectants, wood creosote, and a number of market articles.

The refining processes, which are largely secret, are not the same at all plants, while the products sold are far from uniform.

Since few plants operate under the same conditions, and since a number of products may be obtained from the tar and crude turpentine, it is difficult to estimate the amount of products obtained from yellow pine. Moreover, the wood itself varies widely in resinous content. Heavy rich "lightwood" contains the largest quantities of turpentine and other oils, whereas other kinds of "lightwood" may yield but little. Sapwood yields the least. The following table shows as nearly as practicable the ordinary yields per cord of wood obtained in practice by the destructive process:

Refined turpentine	7 to 12 gallons.
Total oils, including tar.....	50 to 75 gallons.
Tar	40 to 60 gallons.
Charcoal	25 to 35 bushels.

Uses of Products.—The turpentine is used as a second grade, inferior to gum turpentine. There are no recognized grades of destructively distilled turpentine and the composition of the turpentine from different plants is not uniform. Formerly it was poorly refined; it is now made practically colorless. In the refining, certain heavy oils are obtained, which, when combined with similar heavy oils from the tar, are made into "pine oils," used as disinfectants, paint dryers, wood preservatives, etc. One of the uses for the tar is cable coating. The uses of the acetate of lime, in this case "brown acetate," have already been mentioned. The charcoal is burned at the plant or sold for fuel. The pyroligneous acid in its crude form is occasionally sold, although most of it goes to waste.

Several causes have led to many failures among plants of this kind. One of these was bad management. Men engaged in the business, without training or a knowledge of the market, expected an immediate demand for the products. Another cause was the use of inferior retorts, which in many cases were made of thin steel and so were quickly burned out. A third was lack of perseverance when difficulties arose.

STEAM DISTILLATION OF YELLOW PINE.

The plants which distill wood by the steam method are located in the yellow pine belt. In general, the wood is the same as that used for the destructive distillation of yellow pine, but is separated into classes. Steam plants use the richest wood that can be secured, since turpentine is the only valuable product, although the wood after extraction is used for fuel. The wood is divided into three classes: (1) The rich "lightwood," of which several grades are used; (2) stumps, which are also rich in turpentine; and (3) sawmill waste, which includes sawdust, butt cuts, and slabs. All wood must be "hogged" into chips before it is placed in the retorts.

Apparatus.—Both vertical and horizontal retorts are successfully used. But the wood is treated by two different methods, one using superheated steam under low pressure and the other saturated steam under higher pressure.

With superheated steam a vertical retort is used, and the steam, before entering the retort, passes through a superheater, which raises its temperature high enough to readily volatilize the turpentine. From the condensers the distillates run into a separator.

For saturated steam several sorts of retorts are used, and the steam enters them directly from the boiler. There are a number of patented devices, the most important differences in which have to do with methods of charging and discharging. The fundamental idea, however, is to maintain a sufficient pressure of steam, throughout the run, to facilitate rapid extractions. A separator is used, as with superheated steam.

Products.—The products of both processes are crude turpentine and water, in a separator tank, and chips left in the retort. The turpentine, which is lighter than water, floats on the surface and is easily drawn off, ready for refining. The chips, after drying a short time in the air, are suitable for fuel.

In order to obtain a market grade of turpentine, the crude product should be refined by distillation with steam in a copper still. As it comes from the retort its color is slightly yellow.

There is the same variety in methods used as in other kinds of wood distillation, and consequently the same lack of uniformity in the products. Much remains to be learned as to the best method of refining turpentine so as regularly to secure the best grades.

The amount of turpentine obtained from steam distillation varies widely. The wood itself varies greatly in richness. A conservative average per cord is given in the following table (the difference between stumps and "lightwood" is slight enough to be disregarded):

Lightwood:	
Refined turpentine	10 to 15 gallons.
Heavy oils	1 to 3 gallons.
Sawdust:	
Refined turpentine	2 to 4 gallons.
Heavy oils	½ gallon.

The refined turpentine is of reasonably uniform quality, is nearly colorless, has an agreeable odor, and has a fair market at a price somewhat below the market price for gum spirits of turpentine.

COMPARISON OF METHODS.

Comparing the steam methods with the destructive methods, although there is room for difference of opinion, it would seem that the steam distillation is open to the wider development. The successful destructive distillation plants are those which are run by men who have remained in business long enough to establish their processes and methods and the markets for their products. Turpentine, the leading product, is probably produced less expensively by the steam method, and the steam apparatus necessary to handle a given quantity of wood per day, say fifty cords, is easier to operate.

There have been fewer failures in steam distillation than in destructive distillation, perhaps because it is of more recent development and because those promoting the enterprises have [illegible] takes of their predecesso[illegible] failed, mainly because th[illegible] selves with the fundamen[illegible] successful construction a[illegible]

The figures given above [illegible] yields by destructive and steam [illegible] same grade of wood, but simply the yi[illegible] the two methods under actual condit[illegible] point of fact, very different grades of w[illegible]

There is but scanty published info[illegible] properties of the turpentines produce[illegible] processes in America, or on their act[illegible] paint and varnish business. Up to th[illegible] turpentines are merely competitors of [illegible]

AN ENGLISH COMMERCIAL VEHICLE TEST.

SOME NEW DATA AND THEIR VALUE.

The report of the committee of the Royal Automobile Club of England upon the commercial vehicle tests held last fall has just been made. While the tests were comprehensive, the committee does not believe they were sufficiently lengthy to bring out anything more than the radical faults and weaknesses of the various machines entered and to allow of some general conclusions being drawn. That part of the report which is the most interesting follows:

For useful loads exceeding three tons the tractor is the most economical for general haulage. Where speeds are required which are too high for the tractor, the internal-combustion-engined lorry mounted on rubber tires becomes a necessity. The steam lorry, although it possesses the disadvantage of large axle weights, can with advantage be employed where high speeds are not required, and where the loads have to be delivered at quays or places in which the tractor with its trailer could not be so readily maneuvered.

The gasoline lorries submitted were capable of speeds on the road which were excessive, and should not be tolerated. A general reduction of gear ratios seems a necessity, and would result in greater economy, inappreciable loss in average speed on the road and less wear and tear of both road and vehicle. The cost of upkeep increases very rapidly with increase of road speed, and, although the true economic speed has not yet been determined, high maximum road speeds should be avoided as a general rule in commercial vehicles.

The reliability and regularity of running throughout was remarkable. The condition of the majority of the vehicles after the trials was on the whole satisfactory. The amount of wear on the parts was in many cases inappreciable; but some manufacturers have still much to learn, as regards design and the selection of material, before they arrive at a vehicle showing low cost of maintenance and durability. A striking feature in the trials was the successful use of India rubber tires carrying heavy loads up to five tons. About 90 per cent of the vehicles, excluding tractors, had rubber tires, which gave on the whole remarkably little trouble, notwithstanding the high temperature recorded by the thermometer on several days of the trial. It was noted that on more than one occasion, after a rapid run, the hubs of those wheels fitted with ball bearings remained cool, while many of those not so fitted were quite warm, and in one or two cases overheated. This points to diminished friction, and, therefore, lessened wear and tear. There would appear to be a future for a type of vehicle suited for delivery work in the country in cases where speed on the road is of secondary importance, where capital outlay and running cost are required to be reduced to the minimum, and where the loads to be carried would not exceed three tons. The majority of gasoline lorries, being a very high class engineering product, does not fulfill these conditions, and manufacturers might well turn their attention to a cheaper and slower class of vehicle.

The trials have demonstrated that petroleum fuel can be successfully used for internal-combustion-engined lorries in lieu of petroleum spirit; the relative price of these fuels renders it desirable that more general attention should be paid by manufacturers to the possibilities of less volatile fuels, which possess the additional advantage of greater safety in storage and handling. It is regretted that no tractor fitted with an internal combustion engine was entered in the trials. The steam vehicle as at present constructed requires to pick up water at frequent intervals, generally not exceeding 20 to 30 miles. In Great Britain this presents no difficulty, but in the colonies and elsewhere abroad, where mechanical transport can be and is being developed, such facilities for water may not exist. The internal combustion engine, or a steam vehicle fitted with a condenser, is there a necessity, as its use enables the radius of action of the vehicle to be increased to distances exceeding even 150 miles, the limit depending on the capacity of the fuel and water tanks.

As regards the details of construction and design of the vehicles that competed in the trials, it was evident that a very great improvement all round has been made during the past few years. This was notably the case in the matter of wheels, which the earlier trials of the heavy vehicles in this country had proved to be in many cases very defective, and the cause of much trouble. A marked improvement was generally apparent in the attention paid to details, such as wiring, accessibility of nuts, bolts, etc., and ease of removal of those parts which require most attention; there were, however, a f[illegible] in which such points had been totally neglected.

The greatest credit is due to those employed in totally dismantling and reassembling the fifty vehicles on conclusion of the trial, in that, excluding the two days reserved for detailed examination by the judges, the whole of this work was carried out in 3½ days.

In conclusion, it may be said that the commercial vehicle trials have fully justified the heavy expenditure of time and money devoted to them, and it is believed that the opportunity given to the entrants to study the behavior of their own and other competitors' vehicles under the strict conditions of the trials will result in improved design and a benefit not only to themselves but to the ever-increasing number of those to whom facilities for mechanical transport on common roads are of importance.

The medal-winning vehicles in the above test were the following: Unic, De Dion, Lacre, Thornycroft, Halley, Milnes-Daimler, Dennis, Hallford, Darracq-Serpollet, Maudslay, Commercial Car, Savage, Yorkshire, Burrell, and Foster. The Army Council have awarded diplomas to Messrs. J. I. Thornycroft & Co., and the Maudslay Motor Company, and the prize for cleanliness to De Dion Bouton, Ltd.

A CASE OF ACQUIRED COLOR BLINDNESS AND ITS BEARING ON THEORIES OF COLOR PERCEPTION.

By Prof. Best.

Exposure to the sunlight reflected from snow in Arctic and Alpine regions often causes temporary "snow blindness," a disorder characterized by intense inflammation and abnormal sensitiveness to light. The disturbance is caused by the ultra-violet rays of sunlight, which also produce the painful sunburn of high altitudes.

Yet the perception of color, within the range of the visible spectrum, is also affected. Often the snow looks red and one Alpinist took pains to secure a specimen of what appeared to be rose-colored quartz, but on the following day he found it colorless. The writer recently investigated the case of a physician who was brought by two days' wandering over snow-clad mountains, to the condition of red-green blind-

ness which in many persons is congenital and incurable. The case is peculiarly interesting because the patient, a physician endowed previously (and subsequently) with normal color perception, was able to observe and describe with accuracy the sensations of color-blindness, which cannot be done by a person color-blind from birth. For language was made by and for normal persons, and the color-blind are compelled to employ words which do not accord with their restricted sense of color.

To my patient, during his color-blindness, both the red and the green lanterns of the railway appeared yellow and so did the flame of a match; green postage stamps appeared as brown as brown postage stamps, and oranges as yellow as lemons. The sensations blue and yellow remained unaffected. Systematic tests showed that his condition was precisely that of congenital red-green color-blindness with shortening of the spectrum at the red end.

It is a well-known fact that all spectral and other colors can be matched by various combinations of the same three colors. This fact is the basis of all three-color photographic and printing processes. The theory of color perception which was suggested by Thomas Young more than a hundred years ago and was subsequently developed by Helmholtz assumes that the eye contains nerve fibers or sensitive substances or, in general terms, constituents of three kinds, of which one is affected most strongly by the long waves of the red end of the spectrum, another by the short waves of the violet end, and the third by waves of intermediate length corresponding to the middle or green region. It is assumed, however, that each of these constituents is affected, more or less, by all the rays of the visible spectrum. In accordance with the Young-Helmholtz theory, the sensation of red is experienced when one set of nerves (which may conveniently be called the red nerves) are strongly stimulated while the other sets are but slightly affected, and these effects are produced by the longest waves of the visible spectrum. The production of the sensations of green and violet is explained in a similar way. The sensation of yellow results from nearly equal stimulation of the red and green nerves, the sensation of blue from nearly equal stimulation of the green and violet nerves, and the sensation of white or gray from nearly equal stimulation of all three sets of nerves.

This theory fails to account for the case of my patient. His inability to see the red end of the spectrum or to experience the sensation of red can be explained by a paralysis of the red nerves, but the sensations of yellow (and white) for which these nerves are required by the theory were unimpaired while the sensation of green was wanting.

The simultaneous disappearance of red and green agrees better with Hering's contrast theory of color perception. Hering assumes the existence of two pairs of complementary color sensations, red-green and yellow-blue, each of which pairs produces white by the combination of its two components.

Each of these theories of color perception has able advocates. It is impossible to enter here into detailed analysis of either, but it is obvious that the simultaneous disappearance of red and green in the case of my patient—as in most cases of congenital color-blindness—and his other peculiarities of color-perception can be explained far more easily by the Hering than by the Young-Helmholtz theory.—Translated from Umschau.

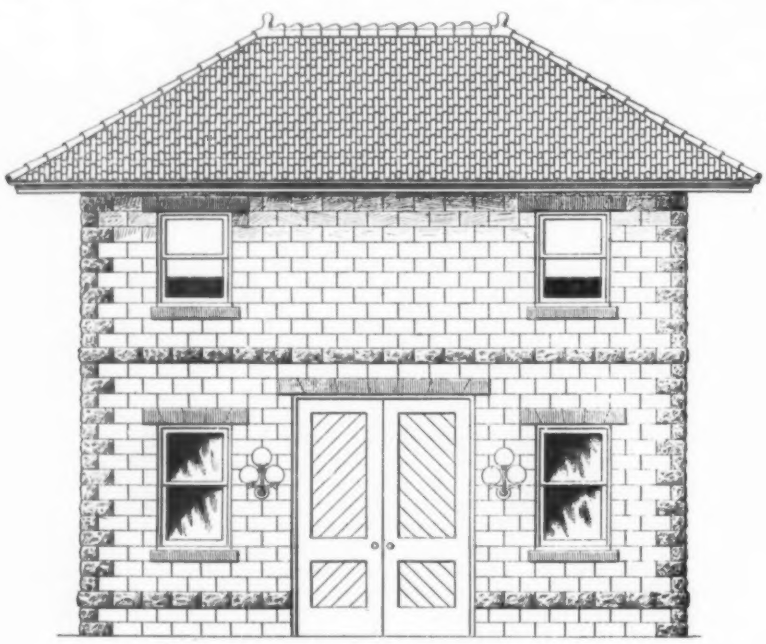
A FIREPROOF GARAGE.*

CONSTRUCTED OF CEMENT BLOCKS.

BY GEORGE E. WALSH.

Absolutely fireproof garages are important necessities of the day, and their construction out of high fire-resisting material requires considerable study of local conditions.

An absolutely fireproof garage is not only possible of construction, but the problem offers few difficult features which the ordinary architect cannot meet. The first essential is to eliminate wood or combustible matter entirely from the building. The selection of the proper building material and its use in walls, roof, and partitions must then determine the relative success of the undertaking.



FRONT ELEVATION.

The peculiar adaptability of hollow terra cotta blocks for this work must be apparent. Their high fire-resisting qualities, durability, great strength, and lightness make them ideal units for building a private garage. The garage can be constructed along simple, artistic lines so that every part of it is absolutely fireproof, and an interior fire started from leaking gasoline could do no more than burn up the fuel and such interior furnishings as might come in contact with it.

A private garage built of hollow terra cotta blocks should have the foundations laid on concrete footings, with the 8 x 16-inch blocks placed lengthwise with the walls. Each course should be laid up in Portland cement mortar composed of five parts of lime mortar to one part of cement, lime to be freshly burned and sand clean and sharp. On the top of the fourth course of the foundation the walls begin with the 8 x 8 blocks, with the interior openings running vertical. The webs of the foundation blocks are from ½ to ¾ inch thick, giving an ultimate strength of 2,500 pounds per square inch and a total carrying load of 80,000 pounds.

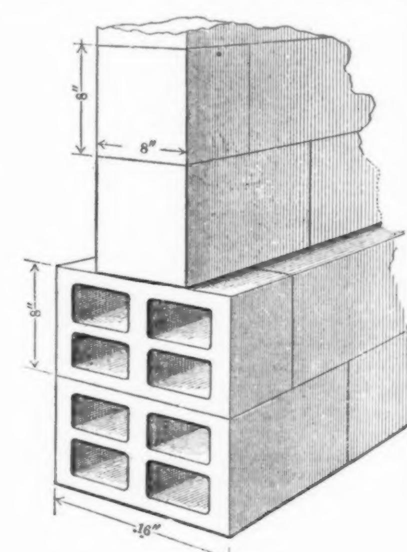
The artistic effect of the walls is enhanced by using rock-faced blocks for the water table, quoins, and band course above the first story. The window sills and lintels are formed of tool-faced blocks, which add sufficient contrast to the plain walls to insure a pleasing result.

The floor of the garage should be composed of concrete, 3 parts cinders and 1 of Portland cement, with a finishing coat of cement and fine sand, making the total thickness 4 inches. The concrete flooring is brought up flush to the edges of the wall blocks, and a slight curve given to it to avoid sharp corners for dirt and dust to lodge in. The flushing of the garage floor with water for cleaning purposes will be greatly facilitated in this way. The collection of grease and oil in the corners of the average garage accounts for a good deal of the disagreeable odors.

The construction of the second-story floor in a thoroughly fireproof manner requires the use of a small amount of structural iron. Wooden beams can be used for such a floor support, and terra cotta bricks can be attached to the underside to protect them from fire, but to make the garage absolutely fireproof only metal, terra cotta, and concrete should be employed. This suggests the long span terra-cotta arch. The principle of this form of flooring is based on transverse steel wires running straight from bearing to bearing, with small wires interwoven with them at short intervals. The line of natural tension is in the line of the bearing strain, and the floor does not deflect under any safe load indicated.

Over and through these wires cement is placed for uniting and supporting the tile blocks. When the cement hardens a complete monolithic floor of cement and hollow blocks is formed, which is not only absolutely fireproof, but exceptionally strong and rigid. In tests made with this type of floor a weight of 733 pounds, live load, to each superficial foot was distributed, so that a total load of 187,680 pounds was carried on the floor with a clear span of 16 feet between girders.

CROSS-SECTION OF FLOOR CONSTRUCTION.



DETAIL OF FOUNDATION WALL.

For a private garage a much lighter floor would be required unless the upper story was to be employed as a storage room for automobiles, with a lift connecting the two floors. This is sometimes desirable on a country estate where a number of machines are kept. The load capacity of the floor would then have to be calculated, so that two or more heavy touring cars could be stored safely upstairs.

In spans of 5 to 20 feet, the ultimate strength of the tile floor is carefully calculated, according to the thickness of the tile. With a clear span of 20 feet, 12-inch tile would give an ultimate strength of 572 pounds per square foot, and with 6-inch tile 142 pounds. For ordinary garage purposes the 6-inch tile would thus answer all purposes on a 20-foot span. With a span of 10 feet, the strength of the floor with smaller tiles is greatly increased. With only a 10-foot span tiles 4 inches thick would give a carrying capacity of 335 pounds to the square foot, and with 3-inch tile a strength of 220 pounds.

Where a 1 or 2-inch floor surface of Portland cement is used over the tile blocks, the strength of the span is further increased. Where the steel rods and wires are supported only on two sides, a 10-foot span, with 3-inch tile, will have an ultimate strength of 560 pounds per square foot with 1-inch Portland cement floor surface, and 1,140 pounds with a 2-inch surface. When the sup-

* Abstracted from Carpentry and Building.

ports of the wires are on four sides the floor will carry a much greater load than any of the above.

This system of floor construction dispenses with steel beams, and stretches from girder to girder or wall to wall. Light steel girders riveted at each corner and fitted in the wall of hollow blocks carry the large steel wires and the smaller transverse wires interwoven with them. Where it is desirable to reduce a 20-foot span to half that width, a center I-beam runs across the middle of the floor through which the steel wires pass on their way from girder to girder.

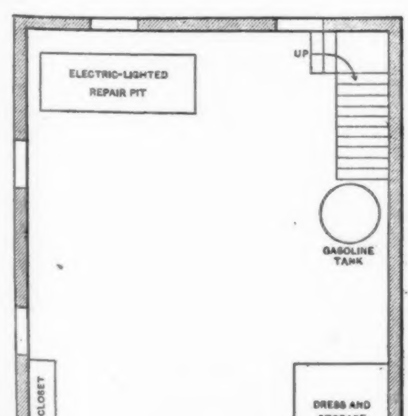
The 16-inch I-beams and girders can be used for this purpose. If shallow girders and beams are used the blocks may be set only 1 inch below the level of the floor. The wire truss reinforcement used in this system is shipped to the building in reels, and can be cut to proper lengths as the job requires. Special hollow blocks are made in sections to fit around the ends and corners of the girders and beams, so that every part of the metal work is incased in fireproof material.

The cost of this system of hollow-block floors averages 30 cents per square foot put in the building, but conditions of labor and cost of cement may modify this to some extent. When the remarkable strength and durability of such a floor is considered in connection with its fireproof nature, the cost is not so great as to deter one from adopting it where the garage, placed near the house or barns, forms a constant menace to property.

Roof beams and rafters of light structural steel to carry tile, metal, or slate shingles should cost upward of $100 more than if wood were employed, but in the end the former would prove the cheaper. The industry of rolling light steel beams, girders, and rafters for this type of fireproof structure is in its infancy, but the demand for them is so steadily increasing that the cost must eventually come down. The steel beams are laid directly on the top course of special joist blocks, which are cut away at the end to permit a snug fit. The blocks surround every part of the metal and completely protect it from any exposure to fire.

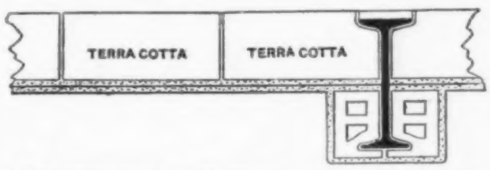
The roof rafters rise from the beams at the desired angle and are secured at the peak in the ordinary way. The hollow terra-cotta blocks are fitted between these rafters, with light tension rods to hold them in position. Where slate or roofing tiles are to be nailed on the outside full porous terra-cotta roof blocks should be used. Nails can be driven in the porous blocks without breaking them, and they hold nearly as firmly as if driven in concrete before it has firmly set. Roofing tile or corrugated iron or metal shingles can be used for the exterior finish just as desired. The pitch of the roof and its exterior finish in any one of the non-combustible materials are questions which local conditions must determine. The chief aim is to secure a harmonious ensemble without reducing the fireproof qualities of the structure.

For this reason the stairway leading from the first floor should be of metal. A straight or spiral stairway exposed on all sides reduces the fire hazard, and is essential for the ordinary garage, even when a lift is provided for handling the automobiles. The design for the living quarters of the chauffeur on the second floor can be readily changed to make storage accommodations for the machines. In this case no partitions are required, nor finishing of walls and ceilings. The exposed surface of the bonded terra-cotta blocks will not be an unpleasant effect.



MAIN FLOOR.

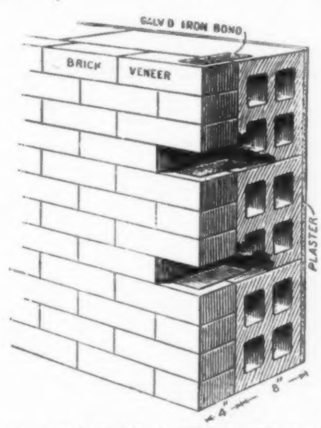
The same is true of the main floor. The neutral tints of the blocks, with very light joints of cement mortar, form a practical interior wall and ceiling, which is better than a rough finish in plaster. If plaster is desired, no furring is necessary, as blocks should be used to which plaster can be directly applied. The only partitions required for this floor are those dividing the tool closet and the dressing or storage room from the rest of the place. Three-inch partition blocks can be used safely up to a height of 12 feet, but above this 4-inch blocks are employed. Two-inch partition blocks are sometimes used, but they require reinforcement of metal. Semiporous and full porous blocks are employed for partition purposes, and every alternate course should be made full porous. This will permit the nailing or screwing of anything in the walls for holding tools or clothes. The partition blocks come in



LONGITUDINAL SECTION OF FLOOR CONSTRUCTION, SHOWING STEEL WIRE RUNNING FROM BEARING TO BEARING.

standard sizes of 12 x 12 and 8 x 12, but special sizes are made for the trade at only slight extra expense.

As a further precaution against fire, the gasoline tank should be inclosed in a terra-cotta closet by itself. This would permit of no leak or danger from fire from the outside. With a properly protected gasoline tank smoking in the garage could be indulged in without extra hazard. The electric light repair kit should be depressed at least 2 feet below the floor level and lined throughout with concrete. Repair to the under part of the automobiles could be easily made in the



DETAIL OF BRICK VENEERED HOLLOW BLOCK TERRA COTTA WALL.

private garage by the chauffeur with such a kit provided and considerable delay and expense would thus be saved.

Doors and windows of the garage, to carry out the absolutely fireproof idea, should be made of metal or at least of wood covered with metal. The total elimination of wood is one of the important considerations of the whole question. Half the value of a fireproof building is nullified if the interior trim is finished in wood or with wooden joists, beams, and rafters. The difference in the insurance rate on the buildings is an item which should also be taken into consideration.

Simple and direct lines have been followed in the building of the garage, and the final cost is affected considerably thereby. The superficial feet of partitions are relatively few, and all unnecessary interior finish is avoided. The cost of a 3-inch partition is about 11 cents per square foot of surface, and of a 4-inch partition slightly less than 12 cents. A 6-inch partition of full porous and semiporous terra-cotta hollow blocks can be put up in walls for about 13 cents per square foot. The relative cost of partitions of a fireproof nature, even for the upper story to divide the living rooms for the chauffeur, is so low that it is economy to adopt them.

The outside walls of 8-inch blocks cost about 26 cents per square foot, and with 4-inch furring 30 cents. The foundation blocks 16 inches thick should cost about 45 cents per square foot. The number of square feet of walls, partitions, and floors will thus enable the architect to reach an approximate estimate of the total cost of the garage of any given size. An average cost of a garage of this type can be made as low as 16 to 17 cents per cubic foot, including the use of light steel beams, girders, and roof rafters. If wooden joists and rafters are substituted the cost is reduced by about $150. In using wooden beams and rafters the cost of protecting them with 2-inch ceiling blocks secured to the under side by screws and washers is an important labor item. This method of fireproofing wooden beams over boiler rooms of old plants has been employed successfully in many places, and in fireproofing some of the old tenements in New York it has been recommended by the Tenement Commission.

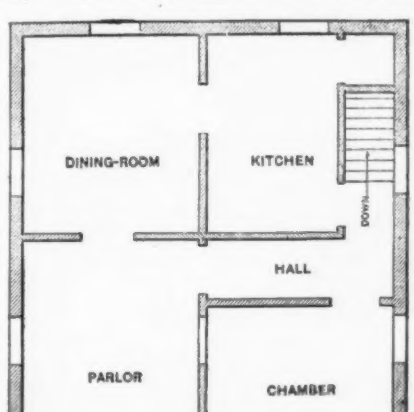
The improvement of the exterior of the garage by either stucco work or brick veneering to harmonize with other structures on the place is merely a matter of slight extra expense. A thin veneer of bricks of any color can be added to the garage at a cost of 30 to 40 cents per square foot, depending upon the cost in thickness of the bricks. With fine pressed bricks at $29 per 1,000 a 4-inch veneer would average 35 cents per square foot. The galvanized bonds, which come with the hollow blocks, when specified, are used at every fourth course, as shown in detail, so that the veneer is firmly anchored to the tile wall. This gives a 12-inch wall of brick and tile of the most substantial nature—fireproof, weatherproof, and practically indestructible.

An exterior of rough casting or stucco work for a private garage yields unusually artistic effects, especially on a country estate where the living house is of stucco work. With two coats of stucco, at least ⅞ inch thick, composed of 3 parts of clean, sharp sand, 1 part Portland cement, and 2 per cent of total weight of hydrated lime, the work should cost not more than 75 cents per yard, and it may be done in some localities as low as 50 cents. The application of the rough casting should be made with reasonable care by experts to secure uniformity of surface and lasting qualities. The exterior of the blocks is prepared for receiving the plaster without any further work, other than thoroughly soaking with water just previous to application. The mortar must be well set before using, and the workmen must tool it constantly on the walls until hard enough to retain its position.

From these figures it will be seen that an absolutely fireproof private garage can be constructed with ample space for all purposes at prices ranging from $1,500 to $2,500. The higher cost includes the best stucco exterior or veneer of good pressed bricks, with metal doors and stairs, fireproof block partitions, and floors built according to the long-span system. The building should be lighted by electricity to reduce the fire hazard, and drain pipes designed and laid so that any leakage of gasoline will be conducted away from any other building.

WHITE AND RED MEATS.

It was largely as the result of the work of Offer and Rosenquist, published in 1899, that the current view regarding the difference between the red and the white meats as affecting metabolism was modified, and it came to be generally accepted that from the analytical standpoint at least there was but little distinction to be made between them. This belief, although apparently founded on reliable scientific observation, has not been entirely in accord with the more or less empirical experiences of those accustomed to treat large numbers of patients suffering from such diseases as gout and nephritis. It has been pointed out, notably by Senator, that while Offer and Rosenquist's observations showed that as far as raw meat was concerned the differences between the amounts of nitrogenous extractives and bases in the red and white varieties were so slight as to be practically negligible, it remained to be demonstrated that the process of cooking and the manner in which this was done did not alter the conditions. This question has been taken up by Adler (Berliner klinische Wochenscrift), who presents the records of analyses of numerous meats both in the raw and cooked condition. While his results on raw meats correspond closely with those of the previous investigators, he found on comparing veal and beef that both frying and boiling caused the extractives of the former to be reduced to about one-fifth of their raw amounts, while with the beef the difference was unimportant. Analyses of other meats gave similar results, and he concludes that in the cooked condition



SECOND FLOOR.

there is a sufficient difference between extractive content of red and white meats, particularly beef and veal, to justify a distinction between the two. Cooking, therefore, seems to cause white meats to lose more of their extractives than is the case with red, and taking for granted a deleterious property on the part of the nitrogenous extractives, the clinical observation that in certain maladies red meats are injurious finds analytical confirmation.—Medical Record.

THE NEW U. S. MILITARY DIRIGIBLE BALLOON.

PLANS OF A TWO-MAN AIRSHIP OF DISTINCTIVE AMERICAN DESIGN.

REALIZING the important place aeronautics is rapidly assuming among the leading nations of the world, our War Department last July formed an aeronautic division of the Signal Corps and secured several balloons. The latest aerial craft that has been contracted for is a small two-man dirigible balloon, which is to be used to train the men of the aeronautic division in the operation of this kind of aerial vessel. The balloon is being constructed by Capt. Thomas S. Baldwin, the pioneer dirigible balloonist of America, and it embodies all the best ideas which he has had as the result of his long practical experience in navigating the air. Particulars regarding this new dirigible follow:

ENVELOPE.

The gas bag of the new dirigible is ogival in shape. The silk used in its construction is in two layers cemented together and with a layer of waterproof substance between. This material has a breaking strength of 75 pounds in either direction per inch width. The length of the bag is 58 feet; its greatest diameter, 16 feet, and its smallest diameter, 14 feet. Its capacity is about 8,000 cubic feet. The envelope is made up of three layers of material running fore and aft and provided with reinforcements where required. A twelve-inch plunger valve is located at the top, and a ten-inch pressure valve at the bottom. The inflating neck is 6 inches in diameter, and the ripping strip is 5 feet long.

NETTING.

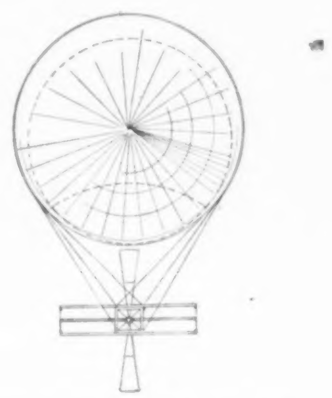
The entire envelope is incased in square-mesh linen netting, having a working strain of 9,000 pounds. This netting is woven in the manner described in patent No. 851,481 granted to Capt. Thomas S. Baldwin, and application for which was filed November 21, 1904. The netting suspension is so arranged that when on an even keel the forward end will have an upward tendency, causing the pressure of the gas to be strongest where it is met with the greatest resistance. The under part of the gas bag, where the suspension cords leave the netting, is covered with elastic bands capable of contracting the envelope an amount equal to the displacement of a ballonet and thus of holding the envelope tight at all times. The netting is so adjusted that in case of collapse it would form a parachute and permit a safe descent. The gas bag is attached to the frame with the three-way suspension shown, which holds the gas bag and frame absolutely rigid.

FRAME.

The frame is made square in cross-section of 1¼ x 1¼-inch spruce sticks, bolted together with ⅝ x ⅞-inch strips. The operator's section is 3 x 3 x 6 feet long. The frame is built in sections in convenient lengths for shipment. As can be seen from the drawings, it is thoroughly trussed.

PROPELLERS, PLANES, AND RUDDER.

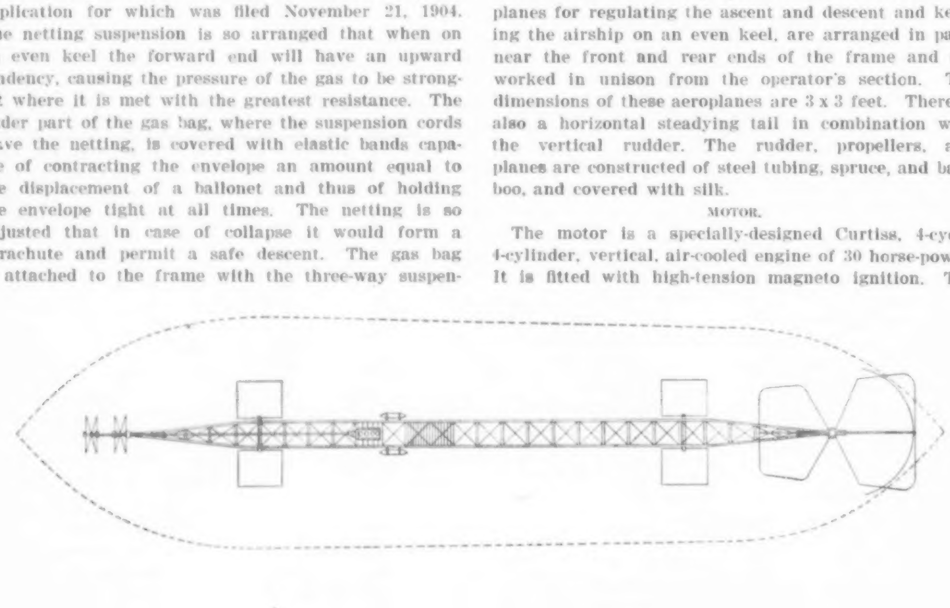
The two propellers are placed at the front end of the frame and made to revolve in opposite directions. They have a diameter of 8 feet, with a pitch slightly less than the diameter. The propellers revolve at a speed of about 250 revolutions per minute. The propeller shafts are of Shelby steel tubing mounted upon ball and roller bearings. Suitable gears of McAdamite metal furnish a speed reduction of about ten to one from the motor to the propeller shaft. The four aeroplanes for regulating the ascent and descent and keeping the airship on an even keel, are arranged in pairs near the front and rear ends of the frame and are worked in unison from the operator's section. The dimensions of these aeroplanes are 3 x 3 feet. There is also a horizontal steadying tail in combination with the vertical rudder. The rudder, propellers, and planes are constructed of steel tubing, spruce, and bamboo, and covered with silk.



FRONT VIEW OF THE AIRSHIP.

MOTOR.

The motor is a specially-designed Curtiss, 4-cycle, 4-cylinder, vertical, air-cooled engine of 30 horse-power. It is fitted with high-tension magneto ignition. The cylinders are of cast iron, and the crankcase, gears, etc., of the new aluminium alloy, McAdamite. A 4-throw hollow crankshaft of vanadium steel, turning in Parsons' "white brass" bearings, is used. The weight of the motor is approximately 200 pounds. Enough fuel will be carried for a two hours' flight. Capt. Baldwin expects to obtain a speed of at least 16 miles an hour with his new dirigible. It is intended for a speed of 20 miles an hour, but must make 16 at least to be accepted.



PLAN AND ELEVATION OF THE NEW TWO-MAN MILITARY DIRIGIBLE BALLOON FOR THE UNITED STATES SIGNAL CORPS.

HORSE-POWER TESTS AT THE DRIVING WHEELS OF AUTOMOBILES.

THE table printed below gives the results of some tests lately made with the A. C. A. dynamometer to ascertain the amount of power delivered at the rear wheels of a modern automobile. In every case the gear in use was the one with which the maximum horse-power was delivered. The tests show that the loss in the transmission of power from the engine to the rear wheels is about 25 per cent. if the motor is supposed to deliver the horse-power at which it is rated. As no tests were made of the engines alone, however, the results given can only be taken as a general indication of the actual loss of power in transmission.

Certificate Number.	Make of Car.	H. P. Rating.	Type.	Year.	Test Results. Maxim'm H. P. at Wheels.	Miles per Hour.	Gear in Use.
5	Mercedes....	40	Runabout .	1905	29	42	4th
6	Pope Hartford....	30	Touring....	1907	25½	36	3d
7	Westinghouse ...	35-40	Touring ..	1907	30	25½	2d
9	Stoddard-Dayton..	40	Runabout. .	1908	30	43	3d
10	Packard.	30	Runabout. ..	1907	33	12	1st
11	Pierce Arrow. ...	40-6 cyl.	Touring...	1908	30	43	3d
12	Pierce Arrow. ...	28-32	Touring	1906	21½	11	1st
13	Simplex....	50	Touring. .	1907	44	46	3d
14	Packard. ...	24	Limousine...	1906	20¾	13	1st
15	Stoddard-Dayton..	40	Runabout. .	1908	24	44½	3d
16	Oldsmobile. .	35	Runabout....	1908	15	34½	3d
17	Stevens Duryea	30-6 cyl.	Touring.....	1908	26	40	3d
18	Delahaye	8-9	Landaulette..	1907	5¼	25	3d
20	Locomobile......	15-20	Limousine.	1907	13½	7	1st
21	Thomas....	40	Runabout. .	1908	23	40	3d
22	Peerless....	30	Touring.....	1908	33	14	1st
23	Packard.........	30	Touring	1907	35	28	3d

A NEW METHOD OF RECORDING THE SOUNDS OF THE HEART.

GRAPHICAL records of the action of the heart are of great value in the study of mental processes as well as in the diagnosis of diseases of the heart. Prof. Einthoven has recently succeeded in representing the heart's action in "cardiograms" drawn by the electric currents which accompany that action. Other physiologists have employed the microphone in the reproduction of cardiac murmurs, and Frank has photographed them with the aid of a mirror moved by a thin India rubber diaphragm.

Prof. Karl Marbe, of Frankfurt, has discovered that the vibrations of Koenig's manometric flames can be recorded very simply by drawing a strip of white paper through them. Each pulsation of the flame is represented on the paper by a deposit of soot, in the form of an elliptical curve. A record suitable for measurement is obtained by unwinding the ribbon of paper from one reel and winding it up on another, the portion between the reels moving with uniform velocity under a roller beneath which the vibrating flame is placed. The record gives the period of vibration with accuracy and also gives an approximate measure of the amplitude, which is proportional to the minor axis of the elliptical trace.

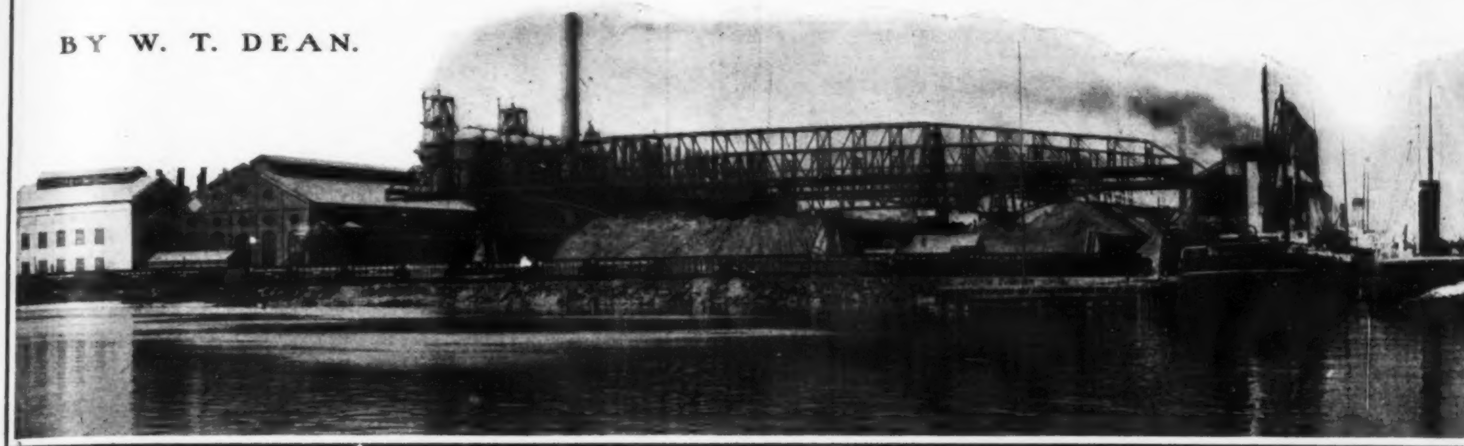
Marbe has employed this method to obtain a graphical record of the sounds of the heart, by causing the action of that organ to affect the flexible diaphragm which bounds the manometric capsule that supplies the flame with gas. The apparatus consists of a brass disk ¼ inch thick, with two perforations, ⅛ inch and 1/50 inch in diameter, fitted with tubulures to which rubber tubes are attached. The lower face of the disk is polished and covered with a very thin sheet of India rubber, which is stretched over a ring of thin cardboard and secured by a brass ring and screws. Below the brass ring is an India rubber ring of the same dimensions. One of the rubber tubes is connected with an acetylene tank, the other with a burner having an orifice 1/50 inch in diameter.

This arrangement produces an exceedingly sensitive flame, owing to the flexibility of the membrane and the small capacity of the manometric capsule formed by the membrane and the brass disk, which are almost in contact. If the rubber ring which forms the base of the apparatus is applied to the chest of the patient an accurate record of the sounds of the heart is made in smoke rings on the moving paper ribbon. The application should be made over the third intercostal space, on the left side of the chest.

This method is much easier of application than any other, an advantage which strongly recommends its employment in general medical practice.—Prometheus.

ELECTRICAL MACHINERY IN STEEL MAKING.*

BY W. T. DEAN.



A CHICAGO LANDING SLIP, SHOWING STEAMERS, ORE UNLOADERS, ORE BRIDGES, AND TRAMP CARS, WITH FURNACES IN THE BACKGROUND.

THE object of this article is to present an outline of the mechanical processes and means of transportation involved in the production of the several forms of commercial steel, without attempting to impart technical information.

The materials required in the production of pig iron, from which nearly all steel is made, are as follows:

First, iron ore, consisting of various oxides of iron of different degrees of purity with respect to the percentages of silicon, manganese, phosphorus, and sulphur contained.

Second, limestone, which is used as a flux.

Third, coke, which acts as a fuel and as a reducing agent when transformed to carbon monoxide. Theoretically, any form of carbon should serve the above purpose, but in modern blast furnace practice, the great size of the furnaces, with the consequent heavy burdens, requires a fuel which combines great resistance to crushing, with a rough structure which will make the entire charge within the furnace as porous as possible. Coke is the only fuel which meets the above requirements.

Fig. 1 is a diagram illustrating the entire process of steel making, beginning with the ore, coke and limestone; the transportation agents bringing together the raw material at the blast furnace, thereafter diverting the pig iron to the Bessemer, or to the open hearth process for converting to steel; after which the raw steel is sent to the various finishing processes.

The principal source of iron ore in this country is the Lake Superior district, and mining is accomplished by open cut working—with steam shovels loading directly into the cars—and by deep mining, usually using the caving system, with narrow gage dump cars and high speed, powerful hoists; the latter automatically dumping the ore into cars on the ground level. The open cut work is now being done, in at least one mine, by means of towers, cable ways, and motor run up an incline and dumped into bins, from which the boats are loaded by gravity; it being possible to fully load a ten-thousand-ton boat in from four to six hours if the bins are full.

From Lake Superior ports the boats must pass through the locks at the Soo—which now pass more tonnage than any other port in the world—and from thence they continue their passage down the lakes, either to Chicago or the Ohio ports, a trip that consumes about four days.

Several methods of unloading are in vogue, the motor-operated grab bucket or clam-shell unloader

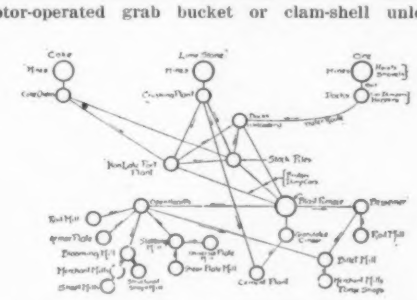


FIG. 1.—DIAGRAM OF STEEL-MAKING PROCESS.

being the fastest device yet developed for the purpose. The original method of unloading involved shoveling the ore into buckets, which were hoisted from the hold by more or less efficient means, and the ore dumped into cars, which were pushed by hand over a structure elevated above the stock piles. Great gangs of laborers from southeastern Europe performed this work a few years ago; now a single operator with a motor-driven unloader displaces one hundred laborers, and five or six operators will unload a ten-thousand-ton boat in four hours.

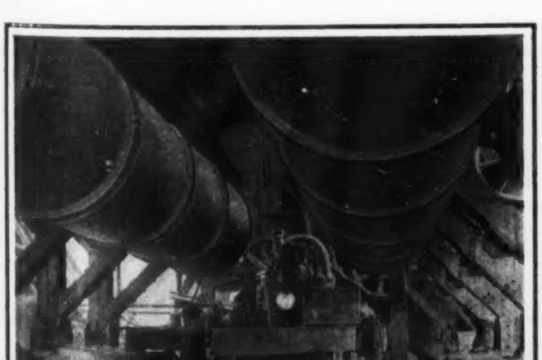
parallel tracks, and pivoted at both supports; so that, within certain limits, it may take any position across the stock yard. A clam-shell grab, similar to that used on the unloader but of greater capacity, digs and transports the ore. So powerful are the grabs that six inches of solidly frozen ore offer no obstacle, and the furnaces may be supplied from the stock piles at any season. The grab bucket is operated by means of steel cables and winding drums; the latter receiving their power from motors. Two separately actuated drums are required for each grab, one for the opening lines, and the other for the closing lines; they are used in conjunction with each other, and divide the load when the grab is fully closed and hoisting begins. The grab is opened by holding the opening lines and releasing the closing lines, the lines being held by means of dynamic and solenoid brakes, or air brakes.

Taking the ore from the trough at the dock, or from the stock piles, the ore bridge deposits it into hopper-bottom bins, or into hopper-bottom transfer cars on top of the bins.

Similar bins are supplied with coke and limestone from cars, and the proper mixture of ores, together with suitable proportions of coke and limestone, are withdrawn from the bottom of the bins and weighed; hopper-bottom scale cars being used in weighing the charge, and accurate records kept by means of tape printing devices.

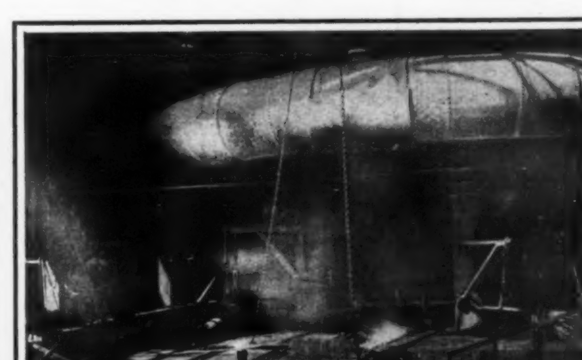
The scale cars are motor-operated, and run on standard gage tracks, which pass over pits into which the buckets or skip hoist cars descend at an angle to clear the tracks.

The charge is hoisted and dumped automatically into the furnace by motor-driven hoists, adjusted so accurately that the position of the cars, when at the top or bottom, never varies more than six inches. All parts of the hoisting machinery are made as strong as possible to prevent the possibility of delays; and



MOTOR-DRIVEN SCALE-CAR UNDER ORE AND LIMESTONE POCKETS.

A BESSEMER CONVERTER.



THE BASE OF A BLAST FURNACE DURING THE CAST.

ELECTRICAL MACHINERY IN STEEL MAKING.

operated grab buckets or excavators. For underground transportation both mules and electric locomotives are used.

However mined, the ore must be transported by rail to the loading docks, where the cars are usually

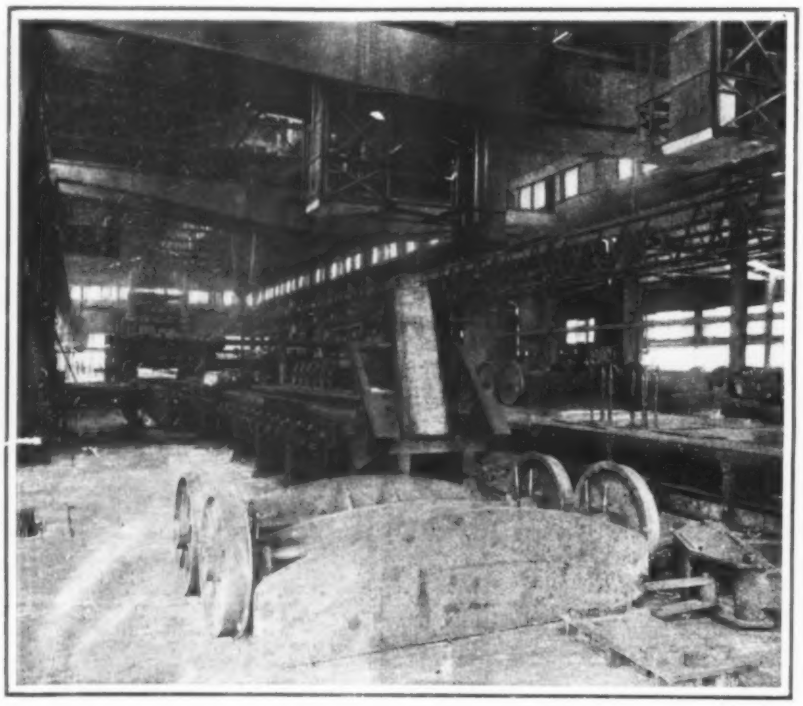
The unloaders deliver the ore into cars under their own structure, or else into a great concrete trough parallel to the dock, from which the ore bridges remove it to stock piles or directly to pockets supplying the furnaces.

The ore bridge is a steel bridge structure, usually about 600 feet long, mounted on multiple trucks on

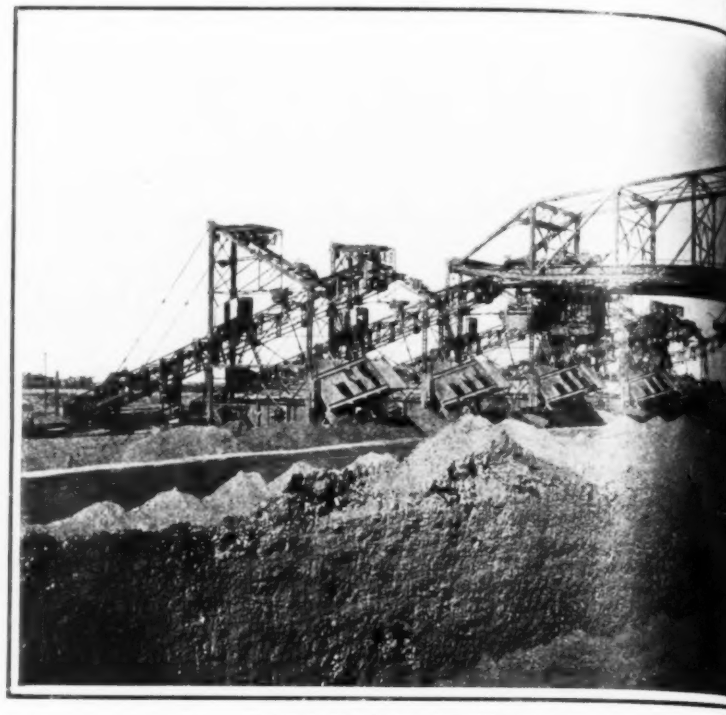
spare motors, controller parts, gears, etc., are kept constantly on hand, for the success of a blast furnace depends very largely upon the absolute regularity of all its functions.

Without going into the chemistry of the complicated reactions taking place in the interior of a blast furnace, it may be said in general that the combination

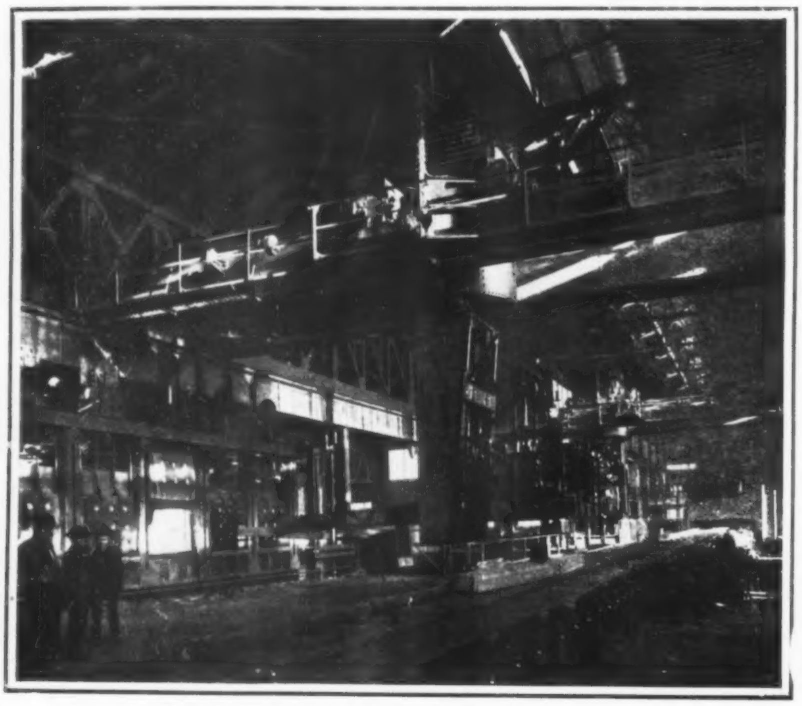
* From a paper read before the Schenectady Section, A.I.E.E.



A SLABBING MILL SHOWING OVERHEAD CRANES AND MOTOR OPERATED TABLE.



AN ORE BRIDGE AND ORE UNLOADERS.



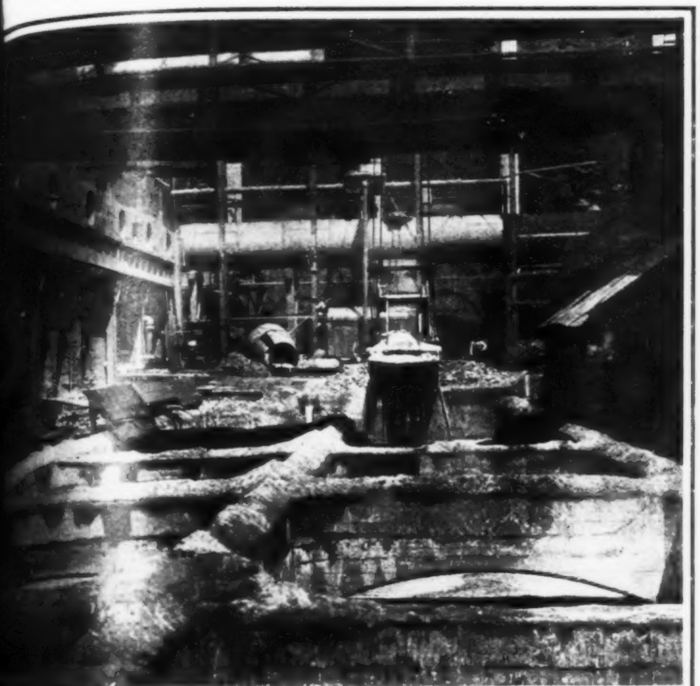
REHEATING DEPARTMENT OF THE STRUCTURAL SHAPE MILL.

SHAFT HOUSE FOR DEEP MINE IN LAKE SUPERIOR REGION.

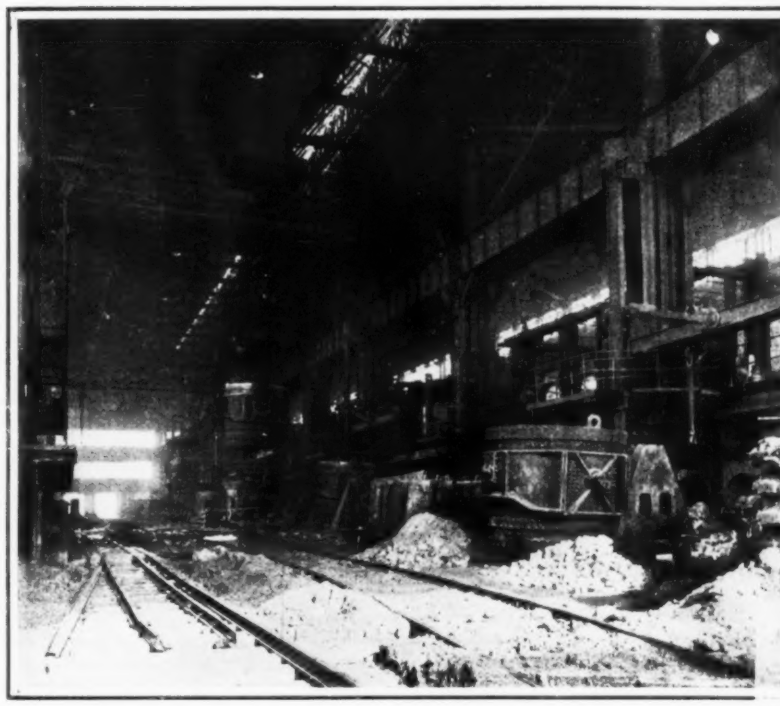
CHARGING SIDE OF OPEN HEARTH PLANT AND CHARGING MACHINE.

OPEN CUT ORE MINING IN THE LAKE SUPERIOR DISTRICT.

ELECTRICAL MACHIN

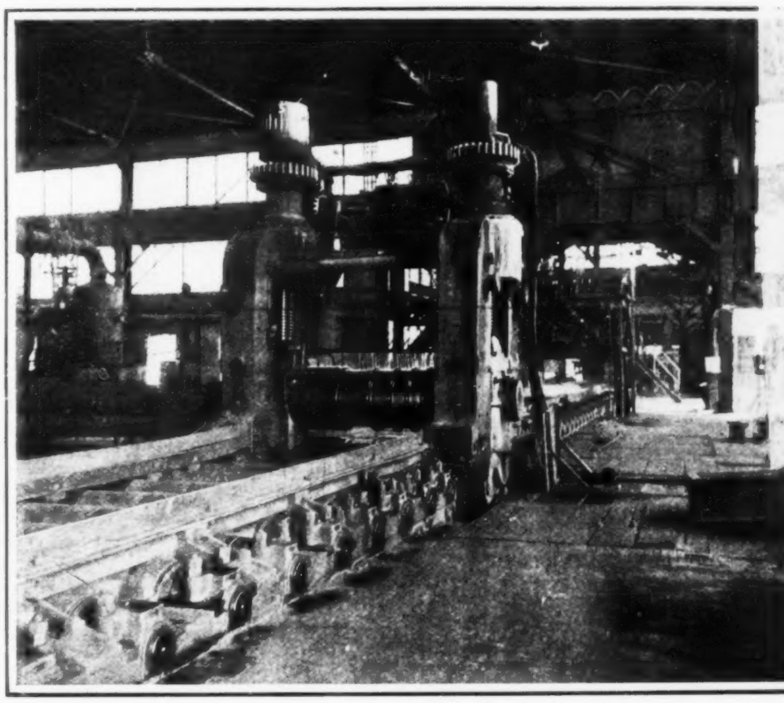


ONCRETE TANK FOR GRANULATING CINDER; WITH CLAM-SHELL GRAB BUCKET.

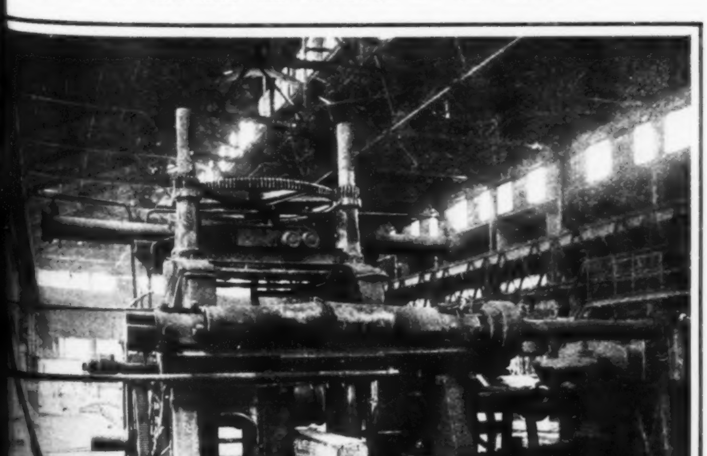


PIT OF DRAWING SIDE OF OPEN HEARTH PLANT WITH 100 LADLE CRANES.

RE BRIDGE WITH CLAM-SHELL GRAB FOR PICKING AND TRANSFERRING ORE.



A BLOOMING MILL WITH MOTOR DRIVEN SCREWDOWN MOTION.



A SLABBING MILL, SHOWING VERTICAL AND HORIZONTAL ROLLS.

A STRUCTURAL SHAPE MILL WITH TRAVELING TILTING TABLES.

, MACHIN[ERY IN] STEEL MAKING.

of fuel, flux, ore, and heated air under pressure, produces pig iron, slag, and combustible gas.

The pig iron is tapped out at intervals of four hours through an orifice near the bottom of the hearth, while the slag is tapped out as often as is necessary through the "cinder notch," which is located some four feet higher than the iron tapping hole. The gas flows continuously, and is used in part to heat the stoves, the excess being burned under boilers to produce steam, used in internal combustion engines, or allowed to escape into the atmosphere.

The molten pig iron is transferred in special ladle cars to the Bessemer or open hearth department, as the case may be, while the slag is hauled away in molten form in "cinder pots," or is granulated, by means of water, for the manufacture of cement.

The Bessemer process is too well known to need extensive description. The pig iron, still molten from the blast furnace, is poured into a large caldron or "mixer," where the product of several furnaces may be mingled and averaged; still molten it is transferred in quantities of about fifteen tons to the Bessemer converter, the pig iron being poured into the top of the converter, which is partially tipped downward for the purpose; air blast is then turned on and the vessel turned upright.

After being "blown" for the required length of time (as judged by the color of the flame, which varies from dark orange to white), the vessel is partially turned down, the blast shut off, and spiegel-eisen added.

The length of the "blow" varies from seven to fifteen minutes, depending largely upon the amount of silicon in the pig iron. The blowing process reduces the pig iron to nearly pure iron, the spiegel-eisen is added to bring the carbon and manganese contents to the specified figure.

After the addition of spiegel-eisen, the vessel is immediately turned down and the contents poured into a waiting ladle, from whence it is poured into cast-iron molds, on small flat cars called "turtle backs." The steel chills upon contact with the molds, and the latter are stripped off within from five to ten minutes after casting, leaving the ingots, as the steel is now called, red hot and solid on the exterior but still soft, or even molten, within.

The ingots are now quickly transferred to the rail mill reheating furnaces, or to the "soaking pits," where a high homogeneous temperature throughout the ingot is obtained in less than two hours. They are then drawn by electric ingot cranes, and are transferred over motor-driven tables to the blooming mill, where the first reduction in section is made. From three to seven passes are made in the blooming mill and the product is called blooms.

The blooms are then sheared into lengths which will produce from two to four rails of the weight desired, and about 15 per cent of the end of the bloom goes into scrap, in order to reduce the percentage of defective rails, as this portion of the bloom is the part most likely to be lacking in homogeneity.

The sheared blooms pass through some fifteen stands of rolls, being gradually reduced in section and elongated until the finished shape is attained, when hot-saws cut them into commercial lengths.

The entire time from ingot to finished rail is about 90 seconds, and an ingot is bloomed every 35 seconds. When sawed to length the rails are still at a bright red heat, and they must be allowed to lie on the cooling beds some time before being straightened, drilled, and shipped.

The Bessemer converter requires about ten minutes to produce fifteen tons of steel. The open hearth process handles larger quantities of metal but is a much slower operation, a complete reaction requiring about eleven hours. As a consequence, the open hearth process is costly; on the other hand it is certain of results, and many ores not suitable for the Bessemer process may be used. The demands of the railroads for better rails, and the increasing scarcity of Bessemer ores, are rapidly retiring the Bessemer process. In fact, no Bessemer plants are under construction or are contemplated at the present time.

The open hearth furnace is a large, shallow vessel, in which approximately equal portions of pig iron and cold scrap steel are melted by means of a gas flame. Suitable fluxes are added as required, forming a protecting coating over the top of the bath. The temperatures attained are so high that the steel boils violently. Samples are taken at intervals, and the furnace is tapped when the desired analyses are obtained.

All of the molten metal, as well as the cold scrap about an open hearth plant, is handled by means of motor-driven machines; such as charging cars and pit cranes. The pit cranes are usually of about one hundred tons capacity, as the entire cast of a furnace, weighing sixty tons or more, must be tapped at one time and into one large ladle suspended from the crane. From the ladle the steel is tapped into ingot molds, as in the Bessemer process.

In addition to operating the charging cars, cranes, rail mill, etc., motors are used to drive the various other mills, viz., the slabbing, shear plate, blooming, and structural mills. The first of these, i. e., the slabbing mill, is a form of blooming mill equipped with vertical as well as horizontal rolls, and produces slabs of suitable thickness and width for further rolling in a shear plate mill or a universal plate mill.

A shear plate mill may be defined as a mill for rolling plates to a definite thickness, without particular regard to width. Such a mill is not provided with vertical rolls, and the product is sheared on both sides and ends to the required shape.

Finished sheared plates are handled about the mill and on the loading docks by electro-magnets attached to traveling cranes.

The blooming mill, when alone, is used to convert ingots into blooms for some subsequent process, and it is frequently used to produce various sized commercial billets as well. The processes are similar to those described when discussing the rail mill.

Blooming mills, when engine-driven, are usually "two high," i. e., have two rolls, and are reversed for each pass. When motors are applied to the driving of such mills, it has been thought best to build the mills "three high," or with three rolls running continuously, the piece passing first between the middle and lower roll, returning between the middle and upper roll.

Blooms for subsequent rolling into channel and I-beams are rolled into a shape roughly approximating the letter I, then reheated and transferred to a structural shape mill.

The structural shape mill differs from the rail mill only in that the several passes are usually made through several roll stands, driven by a single engine; thus necessitating frequent returns over practically the same space. This requires special machinery for transferring the piece from one pass to another; a duty performed by motor-driven traveling tilting tables. The machine consists of a roller table with its driving motors, the whole mounted on motor-driven trucks so as to pass along in front of the several roll stands. The table must also tilt, in order to reach the upper and lower passes of a "three high" mill.

As the piece becomes elongated, means must be provided to support and move the portion which would otherwise overhang the table. For this purpose traveling roller tables are provided behind those just described. The operator—who rides on the front or traveling, tilting table—must be able to control, almost simultaneously, ten distinct motions, as well as watch the piece of steel.

When discussing the blast furnace, the granulating of the slag was mentioned. The slag, or cinder, as it is more commonly called, is allowed to run from the furnace in open channels toward concrete tanks. About ten feet from the end of the run, water is forced at a pressure of 20 pounds into the bottom of the run, and mingles with the stream of molten cinder. The result is a buff colored, light weight, granular substance, known as granulated slag, which is dug out of the tank with motor-driven, clam-shell grabs, and loaded into cars for transfer to the cement plant.

Approximately 55 per cent of crushed limestone is added during the process of cement making, and the mixture is finely divided in tube mills, calcined, and again finely divided in ball and tube mills; making an excellent Portland cement.

The use of electrical machinery has much simplified, and in some cases made possible, the heavier operations in steel-making. The photographs which illustrate electrically driven machines are reproduced through the courtesy of the General Electric Company of Schenectady.

THE BASIS FOR A NEW GEOLOGY.—IV.*

RAISED BEACHES AND THEIR CAUSE.

BY H. W. PEARSON.

Concluded from Supplement No. 1683, page 220.

In the preceding paper it was suggested that the observed incompatibility between the geological doctrines of to-day and the geologic facts recently obtained from the raised beaches, might be eliminated, or explained, if error or uncertainty could anywhere be found in our present fundamental beliefs, it being well established that an uncertain theory can never maintain itself against unquestioned fact.

It has often been found necessary, in the early days of science—at a time when ignorance was almost certain to outweigh information—to construct a basic structure necessarily founded upon inference and speculation rather than upon fact, for the good and sufficient reason that at those epochs observations had been so few and so imperfect, that the law controlling any particular set of phenomena was generally indistinguishable. We were consequently compelled, when in need of a working hypothesis, to rely to some extent upon the imagination if we would make progress in our research.

This practice of adopting at the beginning of an investigation a hypothetical and uncertain explanation for scientific problems, instead of awaiting the more reliable results to be obtained from the slow acquisition of fact, has in many instances led to a rapid increase in knowledge, for the reason that the preliminary guide, so utilized, has subsequently turned out to be the true explanation. In other cases our early speculation having been less happy, a most material check upon progress has resulted, as for instance in our long-enduring acceptance of the astronomical system of Ptolemy.

All branches of science have undergone this experience. Our theories of light, heat, electricity, and chemistry have again and again been subjected to revision, and geology has not escaped a similar fate. In this branch of learning, as in all others, the slow growth of safe deduction from actual observation has alternated with rapid evolution due to fortunate hypotheses. Occasionally, however, we have been forced into the backward path by the temporary adoption of unjustifiable assumption.

We must now call attention to the most important and violent change in geological beliefs, and in the manner of reasoning adopted, that has occurred in the entire history of geology, as it seems to this writer that when this step was taken—a step then thought to be greatly in advance—it is quite probable that *retrogression was the actual result.*

In these remarks we refer to the adoption of the Huttonian doctrine of Fire and Upheaval, and the rejection of the Wernerian system of Water and Stability, as made at the beginning of the last century.

The Neptunian philosophy of Werner (1749-1817) which had possession of the geologic field until the time of Hutton and Playfair, was in its more important articles of faith something as follows:

1. Werner taught that in a remote geologic past the entire surface of the globe had been covered by some submerging ocean, overtopping the highest mountains.

2. From his universal ocean he derived all the primitive rocks, the granites, gneiss, serpentine, porphyry, basalt, etc., by a system of chemical precipitation.

3. Following the deposit of these chemical precipitates there occurred, for some reason unknown to Werner, a great fall in the surface level of the overlying waters; and from these waters of lesser altitudes, he then obtained the recent rocks through a process of sedimentation.

4. Werner taught that all minerals had once been held in solution in this universal ocean, and that their deposition in "rents," and fissures, chiefly in the more elevated and colder rock formations, had been caused by "difference in pressure and other concurring causes."

5. Werner also apparently believed in a rigid and inflexible crust, as he taught that all formations, certain displacements from rents and slides excepted, are in position as originally deposited; and that any observed change in the relative position of sea and land must be due entirely to movements of upheaval or depression in the sea.

The principles above enumerated, as has already been stated, were generally current among scientific men for nearly fifty years preceding 1825; but unbe

* Specially prepared for the Scientific American Supplement.

lievers had become more and more numerous, after the appearance of Hutton's "Theory of the Earth" in 1795, and especially after the new doctrines had been more completely developed by Playfair, in his "Illustrations of the Huttonian Theory" (1802).

The history of this dispute between the rival doctrines of Werner and Hutton, which raged in the early years of the last century, is but seldom given in modern textbooks. A brief statement of the results, however, is contained in Sir Charles Lyell's "Manual" (pp. 44-45), and the matter is set forth quite fully, but with some bias, in Sir A. Geikie's "Founders of Geology."

It was during the period we have just mentioned, shortly after the time of Playfair, that trouble began to descend upon Werner. Slow accretions to knowledge were gradually exposing the fallacy of some of his assumptions.

He and his disciples were placed upon the defensive; they were compelled to make the most far-fetched and extraordinary suggestions to maintain their position, some of which will be hereinafter mentioned. Notwithstanding, however, these difficulties, the older geologists, like Jameson and De Sassure still remained generally faithful to the Wernerian doctrines, although the later students in the field, the younger geologists, were as a rule adopting the system of Hutton, and soon became so numerous as to be able to completely outvote, outtalk, and outnumber the followers of Werner.

The arguments of Hutton, the facts and hypotheses which thus led, a century since, at a time of comparative ignorance, to the rejection of the aqueous theories of Werner and acceptance of the igneous doctrines of Hutton, we will now recapitulate, after which we will re-examine for ourselves in the light of the more perfect knowledge of to-day the basic reasons for the decision above made, that we may be able to appreciate both the strength and the weakness of the early conclusions.

The first and altogether the strongest objection made to Werner's theory by the Huttonians, was the demonstration that his elevated ocean in continuous position over the land would not explain certain facts in the stratified rocks. These observations gave assurance that between the deposition of the several formations the ocean had not remained in its high and fixed position as assumed by Werner, but that many oscillations in the water's level had occurred. It appeared in fact that the elevated seas had often retreated from the high position previously assigned them, and at later periods had again returned to their old level. Moreover, as research and investigation progressed, it seemed necessary to continually add to the number of these vibrations in oceanic surface.

This alternation of deluge and desiccation, evidence of which was repeated again and again in the rock formations, was totally inexplicable by Werner and his followers. They suggested that the waters may have been removed from the earth's surface by the impact of a comet or some other celestial body; but when they attempted to explain how these waters, once removed, could be brought back so as again to cover the highest hills, they became lost in a sea of absurdities.

Steno, Leibnitz, and others conjectured that the oceans may have retreated into great caverns in the earth's interior; but even if caverns of capacity sufficient to engulf an ocean were admitted, there still remained no conceivable force that could cause that subsequent ejection of the waters which the facts of geology required.

The many retreats and returns of an ocean, to which all geology testified, were thus utterly inexplicable by the Wernerians. The more they attempted to evade the problem as to how a repetition of deep submergence alternating with high emergence, many times in regular succession, could be explained, the more they became involved in absurdity. They could not offer consistent cause for even a single disappearance of the waters. Jameson said: "We may be fully convinced of its truth (decrease in the water's level) and are so, although we may not be able to explain it. To know from observation that a great phenomenon took place, is a very different thing from ascertaining how it happened." ("Founders of Geology," p. 118.)

This complete failure of the older doctrines, as above mentioned, was, moreover, coincident with the appearance of the Huttonian theory, now the base of modern geology. This theory maintained that these apparent motions of the sea were really in the land itself, which was rising and falling in an irregular manner under the contractional effects of a cooling earth. To this theory of wrinkling there was at that time no known objection; while the defects and absurdities of the older hypothesis were becoming every day more and more manifest, as has already been shown. These defects in the old system were conclusive. Werner and his theories were utterly routed, and the geologists "were compelled to have recourse to the other alternative, namely, the doctrine that the solid land has been repeatedly moved upward or downward, so as permanently to change its position relatively to the sea." (Sir Charles Lyell's "Manual," fourth ed., p. 44.)

The decision thus arrived at, under the conditions of knowledge then obtaining, was based on unquestionable reasoning, and at the epoch we mention was incontestable. Oscillation in the sea was another absurdity. Oscillation in the land, under the expansion arising from internal fires or the contraction of a cooling crust, as advocated by Hutton, seemed a hundred fold more probable. The base of our present geologic system, the doctrine of *Upheaval by Contraction*, was thus introduced into science. The geologists of the period admitted at the time the uncertainty of the new faith; but groping as they were blindly after the truth, ignorant that any objection could be made to the new theory, they could only accept that which seemed to possess the greatest probability of truth, and consequently their rejection of Werner, their acceptance of Hutton, was beyond criticism.

This decision, we have seen, was arrived at a century since, at a time when geological research was in its infancy, when the knowledge necessary to pass upon such questions as were thus judged, in comparison to the knowledge of to-day, was almost negligible, and long before the physicists had urged the absolute inability of any theory of contraction to explain the rugosities on the earth's surface. Let us now consider, therefore, the merits of the above decision after all accepted conditions of the problem have been submitted to the light of the more perfect understanding of to-day, as to things geological; and especially let us examine what effect the results recently reached by the application of mathematics to problems of the earth's crust may have on a final determination.

One of the first and most pronounced discoveries to be made in such examination is the fact that the most important of all objections made against the Wernerian hypothesis—his inability to explain the retreats and returns of an elevated ocean—*is no longer valid.*

This objection is now, and always was, a mere specter. It was based on ignorance. Good and sufficient cause, with both mathematical and physical support to the contention, can now be given for the submergence of all land of moderate altitudes on the earth's surface, and these floodings may be repeated as many times as may be necessary, as has already been detailed in Part III. of this paper.

The universal ocean of Werner is therefore no longer an absurdity. All geologists agree that the raised beaches existing in all latitudes, to elevations of 1,000 to 3,000 feet, and in basins like Bonneville to perhaps 6,000 to 10,000 feet, are positive evidences of overlying waters. His elevated oceans are therefore physically, mathematically, and geologically necessary, and the former decision of the founders of geology in this matter must be declared void and without effect.

Another assumption of the Huttonian system, in opposition to the water origin of Werner, is that the granites, andesites, dolerites, basalts, and other similar rocks are of volcanic origin; that these formations are in fact lava flows from the fluid contents of a molten interior.

It may seem unnecessary to discuss this question here, as no argument obtained from the raised beaches has yet been presented which antagonizes this position. It may be said, however, that the raised terraces have developed serious opposition to this igneous origin for the granites, which if opportunity offers will be presented in other papers. Meantime we desire only to call attention to the fact that many geologists of to-day are even now questioning this long-established doctrine. J. P. Lesley says in this regard: "Good geologists look upon mountains of granite or syenite no longer as upbursts of molten matter from the interior of the planet, but as sedimentary rocks hardened and crystallized by gentle heat and acid water." ("Iron Ores of Minnesota," Winchell, p. 301.)

Other geologists have affirmed the aqueous origin of the traps and basalts in certain instances. Sir Charles Lyell admits the uncertainty involved in the idea of an igneous origin of granite, and the chemists have insisted that these latter rocks—the granites and the associated formations—always have in their quartz contents the greater specific gravity due to precipitation from solution; never the lesser value due to solidification from a state of fusion.

Therefore uncertainty still prevails in the second important theorem of Hutton. Hence it is perfectly good logic to conclude that the subject of the aqueous or igneous origin of the granites and basalts is yet before us. If scientists still remain in doubt in this matter, after a century of research, the positive acceptance of Hutton's doctrine in the infancy of geology was unjustifiable and must be reconsidered.

Another Huttonian assumption, that all minerals, especially iron ores, had been melted by heat and forcibly injected into the clefts and fissures in the formations, so generally acceptable to the early geologists, we need only refer to, as the idea has long been abandoned. It is now almost universally maintained that all minerals have been deposited from water; but the source of the waters, the source of the minerals they carried in solution, and the direction of the water's flow, whether upward from the earth's interior or downward from the earth's surface, yet remain among the more difficult problems of geology.

Of all those doctrines which were adopted at the time of Werner's downfall, however, the Huttonian idea of the origin of mountain chains, and of ridges of lesser elevation, has been by far the most effective in guiding the research and speculation of subsequent years. In fact, the literature of modern geology has been devoted in greater part to theoretical considerations as to what might have been accomplished by hypothetical foldings and contractions, rather than to the perpetuation and recording of actual observations.

The belief in this system of upheaval, in this idea of a plastic and ever-moving crust, has been so absolute among geologists, it has become so firmly fixed in our geologic philosophy, that it would seem impossible to shake one's faith in the correctness of the principle. However, man is not infallible; he has repeatedly held erroneous beliefs in the past, and will continue to hold them in the future. Let us therefore examine the merits of this doctrine, in the same manner as before, even if the undertaking at the outset appears to partake somewhat of the absurd.

No facts yet presented from the raised beaches, it is true, offer conclusive evidence against the hypothesis of upheaval. This testimony merely assures us that if upheaval of mountains ever occurred, *it could not have taken place in recent times.* The perfection of figure in the beaches, and in the outcrops of the coal beds, affirm since their deposition an absolutely rigid crust. In recent times, therefore, contraction, wrinkling, warping, tilting, and upheaval of crust must be entirely eliminated. The uplift of strata heretofore required by our doctrines, in explanation of the elevated position of the Tertiary rocks for instance, is no longer necessary. We may now utilize an elevated sea to deposit these formations.

This deduction of crustal stability, however, can only be made for the period subsequent to the dawn of the carboniferous. Previous to that epoch there may have been as many disturbances and foldings in the crust as the most exacting follower of Hutton may require, in so far as any objections yet presented from the beaches may be concerned. There are, however, other good reasons, aside from those derived from the ancient shore lines, which forbid the acceptance of this idea of uplift in the rock formations. These are the ever-present, the unanswerable conclusions of physics and mathematics, that crustal movements sufficient to explain mountains of the slightest elevation, *in any geologic age whatever*, are impossible physically, and must be entirely repudiated by the geometers.

The Rev. O. Fisher finds that no rugosity on the earth's surface, cooling during some millions of years from a temperature of 7,000 deg. F., can have exceeded an elevation of 6 or 7 feet. ("Physics of the Earth's Crust," p. 121.)

Lord Kelvin, many years since, stated that the doctrine of contraction as advocated by the British geologists was opposed to the principles of natural philosophy, and urged that a reform in geological speculation had become necessary. ("Physiography," Huxley.)

Major C. E. Dutton says of the wrinkling and contractional hypothesis of mountain upheaval:

"It is quantitatively insufficient and qualitatively inapplicable. It is an explanation which explains nothing which we want to explain." (Phil. Soc. of Wash., Bull., XI., p. 52.)

Other calculations might be presented, but it seems unnecessary. Mathematicians are in agreement in their universal condemnation of that theory of contraction and upheaval which now forms the base of our science. When we add to this that the beaches have shown the idea to be no longer an absolute theoretical necessity to geology, that all faults, folds, contortions, and flexures can be otherwise explained, it would seem that the early decision of our geologic forefathers, like the verdicts we have previously examined, was incompetent and invalid. A physical absurdity should have no place in a permanent structure.

It has been the practice among most geological writers to impress the student with the plausibility of the wrinkling hypothesis, by means of the "wrinkled apple" illustration. This manner of presentation should be abandoned. The simile is unfortunate.

There is no similarity in condition between a body more rigid than steel, which has cooled only at the surface, the interior "not having as yet contracted at all" (Dutton, "Earthquakes," p. 30), and an apple which may have lost 10, 20, 40, or even 80 per cent of its interior contents through evaporation.

There is an argument, originating with Hutton's

disciples, which has been strongly urged as conclusive evidence of motion in the earth's crust, which should also be mentioned in this connection. It seems that on many coast lines the land is apparently rising above, on other coasts it is sinking beneath the sea. It has heretofore been held that these motions were certainly in the land, it being supposed impossible for the sea to rise or fall in one place without being similarly affected in all portions of the globe.

This assumption has recently been shown as erroneous, the motion being really in the sea. (See article "Deformation in the Sea Level," Scientific American Supplement, No. 1661, or the Geolog. Mag., March, 1907.)

We have now accomplished the object of our examination. We have learned that many of our current geological assumptions will not bear analysis. We have learned that some of the fundamentals of geology—adopted a century since under processes at that time beyond criticism—are to-day entirely indefensible, and unworthy the place they occupy at the head of a great science.

These results, however, are not so astonishing as might be supposed. They are the natural sequence from past events. Locke's law says: "Doubtful positions, accepted as truth, keep those in the dark who build on them."

ARCHÆOLOGICAL EXCAVATORS.*

THEIR OBJECTS AND METHODS.

BY DR. AUGUST KOESTER.

Besides the written works of the ancients, a number of actual objects dating from those remote times have come into our hands, which supply us with much valuable information and supplement and explain the old writers, so as to unroll before our eyes a uniformly clear picture of antiquity. To this day they are of the greatest value as unequaled models to our artists and artistic workmen. To increase the number of such antique objects, or where towns and buildings are concerned, to recover at least their foundations, is naturally of great importance, as such new discovery reveals some new phase of antique life, teaches us to understand our existent material better, and enables us with the aid of inscriptions, to fill up many a gap in ancient history.

In comparison with what once existed extremely little has been preserved through the centuries, for war, general confusion, and decline in all spheres of learning, separate us from that great epoch of culture.

What have been preserved down to our days are mainly works of architecture, lasting and strong enough to defy the tooth of time, and protected by the people, as far as they were in constant use. Only in isolated instances have these buildings served the original purpose, down through the centuries, for which they were erected, as for example, that old lighthouse, gray with years, on the northwest coast of Portugal, which, erected in the time of the Roman emperors, to this day, in darkness and in foggy weather, with friendly rays, points out the way to passing ships. With the changes of time most buildings have also changed their purpose and have thereby at the same time, unfortunately, lost some of their originality. Temples were often converted into Christian churches and rebuilt according to the needs of the new cult. In later years some were even realtered in order to serve as mosques. In the middle ages the buildings of Rome were more or less transformed into fortresses, as the former tomb of the Emperor Hadrian, which is still a fortification. The great temple of Edfou was used as dwelling-houses, and up to a short time ago, a whole village was housed within its walls.

Of movable objects, too, indeed, even of works of art, a few were used again and again for some purpose or other, and so escaped destruction. Even in our day sarcophagi are used as baptismal fonts, as reservoirs, or even drinking troughs for cattle. A celebrated marble vase, the work of a noted artist, served as an anchorage post for ships and as a font. To-day it stands in the museum at Naples. The funeral urn of the elder Agrippina became in the thirteenth century the corn measure of the city of Rome.

Photo by F. B. Wright.

NATIVES AT KARNAK, EGYPT, CARRYING AND DUMPING DIRT FROM THE EXCAVATIONS.

The number of such articles which the people took under their protection and handed down through centuries, is, of course, not so great, and most of the antique things now preserved in our museums had in some way or other become buried under the earth, where they remained for a longer or shorter period in safe hiding, while centuries and peoples rush over them unheeded. But how do such objects get into the ground? the antiquarian is continually being asked, especially statues of considerable dimensions.

Photo by F. B. Wright.

TEMPLE OF EDFOU, EGYPT, IN WHICH A WHOLE VILLAGE OF NATIVES LIVED BEFORE IT WAS CLEARED OUT.

It is a well-known fact that in inhabited places the level of the ground is continually rising. Every day new building materials are being brought into the towns, but the rubbish that is taken out is not so considerable, consequently each new building stands somewhat higher than the one which preceded it. By each new paving the streets are raised a little and open squares and gardens grow still faster by reason of the falling leaves, sweepings, etc. In ancient towns, which had a great number of unpaved streets and squares, and where at times whole districts were destroyed by fire or sword and lay unbuilt for centuries, this so-called culture stratum is, of course, considerable.

In this stratum or layer are found many things that were either thrown away and lost, or otherwise accidentally mislaid, and so eventually got under the surface. Still richer in "finds" are the spots on which settlements once stood, which were suddenly destroyed and leveled to the ground by fire, sword, or earthquakes. The most valuable objects were, of course, not left behind, but nevertheless much remained lying under rubbish and ashes. By the action of the weather a layer of fertile soil was formed and a blooming vegetation soon grew over all, and nothing remained to show that the spot now visited occasionally by shepherds was once a flourishing village, until, perhaps centuries later, the favorable situation of the place induced other peoples to settle, where, possibly, after a period of prosperity they suffered the same fate as their predecessors. Thus, for instance, in the course of Schliemann's excavations in Troy, quite a number of towns belonging to the most widely different periods and peoples, were found lying one upon another and still distinctly recognizable by what was left of them.

Floods, too, have carried much under the earth, for when rivers destroy, they spread at the same time a covering of gravel and sand over the ruins, which is in some places of considerable thickness, as in Olympia and in the plain of the Eurotas. It is also sufficiently well known that at times whole towns have been destroyed or buried by volcanic forces, as at Pompeii and the numerous villages adjoining.

For perilous times, moreover, money and other valuables were often hidden away under the ground

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by anxious persons, and many a one went down to the grave bearing his secret with him. Such treasure trove is by no means rare; at Hissarlik, Vettersfelde, and Petrossa, in Roumania, for example, were found great treasures in gold, and at Boscoreale was dug up the famous silver "find," which is now the most prized possession of the Louvre Museum at Paris. Bronze treasure, too, which perhaps is to be regarded as the stock of some manufacturer, is awaiting its resurrection. Near Bologna, for instance, there were found 14,000 bronze utensils, for the most part inclosed in a single huge vessel. Even statues were buried, perhaps by the worshipers of the old religion, trusting in the return of the dominion of their gods.

Courtesy of Dr. Albert T. Clay.

ARAB WOMAN GRINDING CORN IN NATIVE CAMP AT NIPPUR, DURING THE EXCAVATIONS.

But the richest and most numerous hiding places for smaller objects were the abodes of the dead, in consequence of the belief that human beings retained their daily needs even after death. Vessels are found in almost every grave. These consist chiefly of weapons and jewelry. Unfortunately, it was not always articles of full value which were given to the dead. Many things were especially made for this purpose, e. g., shields of lead and wood, gold work of gilded clay, vessels without spouts, and such as were much too small, or otherwise of no practical use, worn-out household utensils, an earring, the mate to which had been lost; metal looking-glasses bent out of all shape, which distorted the face—the main thing was to satisfy appearances. But, for all that, the different contents of the graves are of no mean significance for the science of antiquity on account of their infinite variety and the number of the gifts.

In all ages it has come to pass that objects, which had lain safely buried for a longer or shorter period, have been discovered and brought to light by some happy accident. A thunderstorm rends the earth, a gale scatters a layer of sand, or some river sweeps away what is buried in the sand, and dumps it down somewhere on the bank, as was the case some years ago on the Alpheios, with a helmet which Hieron had dedicated after a victory at sea. The fact that peasants are particularly lucky at finding treasures has already been mentioned by several writers of antiquity, and the peasant working in the field has the best chance of doing so; a furrow is turned up a little deeper, a long waste piece of ground is made arable, or a mound opened up.

Near Portici, a well was being dug and the deposit of ashes covering Herculaneum was thereby disturbed, the catacombs were discovered by puzzolan-diggers, the celebrated find of silver at Hildesheim was brought to light quite by chance, during some operations at the shooting stand there, and some time ago the ruins of the Græco-Roman town of Emporeon were laid bare by some workmen in the province of Gerona in Spain. In the course of more extensive operations, such as the construction of the Anatolian railway, for instance, chance finds are naturally very numerous.

In the beginning nobody but treasure-hunters ever thought of digging in the ground with a set purpose. This branch of industry flourished as far back as the time of the ancients, and to this day plays an important part in the Levant. Unfortunately, however, science but very rarely reaps any advantage from what is gained by the treasure digger, working with his many superstitious arts. Should he find gold and silver, it usually finds its way into the melting pot, as do also very frequently the accidentally discovered hoards or treasures, if only from a fear that some superior, should it be only the cailif of the village, get wind of it and demand his share. On the other hand, should the dreamed-of riches transform themselves into coal and ashes, that is to say, should the find consist only of a cinerary urn and a few vases, objects which they are at a loss what to do with, a kick from a heavy boot soon puts an end to their beauty. The number of statues and inscriptions, too, that have been destroyed by the treasure-hunters and ignorant peasants is not small. In the opinion of the Oriental the treasures are inclosed in the huge inscribed blocks, whose hieroglyphics he himself cannot decipher, and which are so carefully handled, cleaned, washed, studied, and photographed by us. The inscription is the "open sesame," and whoever is able to read it, can take possession of the treasure. But if the treasure is inside, the Oriental reasons that then it must be got out in another way, and so he smashes the stone.

The tombs were, of course, the favorite hunting grounds, and even in the days of antiquity—as follows from Egyptian criminal documents and Greek romances—grave robbery was so very common we might almost say it was a regularly organized profession. Hence, it is that we very frequently find the ancient tombs already broken open, robbed of their most valuable contents, and the remainder in pieces. But these sherds do not always prove that the tomb has been broken into, for the clay vessels were frequently smashed at the burial to prevent the return of the deceased, or from another prevailing belief. For instance, the vessels were put into the tomb with the dead man for his use in the other world, but the deceased did not exist any more—only his soul, if we may call it so; and the soul, of course, cannot use the material parts of the earthly vessels, but only the spirit which still lingers there. The soul of the vessel, therefore, must be set free, the vessel must die—it is broken to pieces.

As for the excavations proper, that is, those which are carried out not for the sake of possession, but in order to ascertain and learn how things were in former times, they were begun at a much earlier period than is generally supposed. Even the Babylonian kings dug for the foundations and building plans of the ruined shrines of the olden time with the object of applying the old rules and regulations to their new structures. In the first few centuries of our era excavations were made in Palestine to discover the place of the crucifixion, the scenes of martyrdom, and the graves of prominent men. In Italy, at the beginning of the twelfth century, people began to take an interest in everything dating from the time of the old Romans, whom they regarded as their forefathers, and made researches in the ground for

Courtesy of Dr. Albert T. Clay.

WORKMEN REMOVING ANCIENT PAVEMENT AT NIPPUR.

The pavement being removed was laid, or relaid, by Naram-Sin, with bricks bearing his father, Sargon's, name, c. 2800 B. C. (?) Just above, 4 to 6 feet thick, is pavement made by Ur-Engur, c. 2450 B. C. Above is pavement of Ur-Ninib, c. 2325 B. C. On top is the pavement of Kadashman-Turgu, XIII century B. C.

relics of the olden time. But these excavations and those of the same kind which were undertaken here and there during the Middle Ages were pure raids, the main purpose being to obtain as great a number as possible of movable objects. They did not trouble themselves in the least about the circumstances under which the objects were found, and nobody thought of turning them to scientific account. Hence it is, also, that we do not even know where many celebrated works of art were discovered, to say nothing of the accompanying circumstances. The statues, being only in very rare cases in perfect preservation, were furnished with arms and legs, and when necessary even with heads, and then served to adorn the gardens and villas of the aristocracy. By this process of completion, more or less clumsily executed, in which, as a rule, filing and polishing of the antique parts were included, much has been spoiled and many a work rendered valueless. It is scarcely necessary to mention that occasionally also little mistakes occurred, and the repairers whose workshops were crammed with antique arms, legs, hands, feet, and heads would sometimes place a masculine head on the statue of a woman, and *vice versa*, or transform a fighting warrior into a fallen one.

Predatory raids in which, in most cases, a great deal was destroyed, are now forbidden by law in nearly all countries concerned, but, nevertheless, they frequently occur in lonely and remote parts, as is proved again and again by the many antique objects cropping up in the art trade.

Archæological excavations, properly so called, are now carried on along definite, methodical lines. We seek not merely for separate objects, but consider the topography, plan, and history of the place in question at all the different periods of its growth and development. It is often not enough for us to excavate a single temple or theater, we lay bare entire towns with their streets, squares, and gymnasia, their baths, libraries, and theaters, their temples, market-places, and factories, their shops, stores, and workshops, and it is no longer Pompeii alone that unfolds before our eyes a picture of the town life of antiquity.

All that we learn from a single one of these excavated towns cannot be told in a few words. First, from the whole plan and style of building we can tell approximately when the town was founded, or whether there had always been upon the site in question a settlement dating from pre-historic times. From the further extension of the settlement we can see that it began to flourish after a certain time, and the course of this growth is, as a rule, not hidden from us. We are hereby able, with the help of the ancient writers, to bring the town into historical and educational connection with other towns and states. Their political significance is deduced from inscriptions; and from the number and splendor of the public buildings, temples, theaters, baths, etc., the prosperity of the community. The quality of the buildings, statues, and other works teaches us in what relations the inhabitants stood to art, whether they followed their own direction in art, had at their disposal their own creative and executive artists, or whether they imported their art. If so, from where, and, furthermore, whether they had enough artistic sense to develop and improve this imported art, or if it starved or ran wild under their hands. We learn something, too, concerning the life of the inhabitants, both in their business intercourse and private life. The sale-rooms, market-places, and shops appear equally distinct. Here dwelt a baker, there a draper, and at this corner there stood an inn. We go into the business rooms and see the arrangements and measures which were necessary to every trade, in some even we find the very tools. In the same manner we learn to know the private houses in their ground plan and structure, with their courts and pillared halls, their state-rooms and gardens, their living rooms and kitchens. Not one side of this antique life is overlooked during such excavations; everywhere we find scattered signs from which we are able to make deductions in this direction or in that.

Such comprehensive excavations, which occupy several years, are, of course, only in very rare cases, undertaken by a private man at his own expense. Scientific research societies, the more important museums, or the state itself here step in, and with sufficient funds carry out the operations on a grand scale, under the guidance of archæologists, assisted by epigraphists, architects, geometricians, etc.

Before beginning such excavations it is necessary above all to find out the right place in which to set the spade, and for this a little luck is needed; however, one will scarcely begin an excavation entirely at haphazard without any signs or traces whatsoever to indicate the presence of antique relics. It is chiefly the ancient writers who show us the way, and in union with them the relics which exist to this day. Of ruined towns, great shrines, castles, and fortresses something—were it only a miserable bit of wall—has been preserved in many cases throughout the centuries, and has still remained visible. Thus at all periods the royal castles of Tiryns and Mycenæ, and the sites of Olympia and Delphi, of Ephesus and Miletus have been known and recognized. But it is more difficult when we have to rely only upon the accounts of traditions, in which, in some cases, the situation of a shrine, or a temple, is accurately described, but often is only casually mentioned or vaguely designated. In such circumstances we must work upon other criteria, and every detail is given significance. The character of the landscape, the nearness of water or mountain peak, the capabilities of defense of the place, etc., are to be carefully noted, the present name of the village, the names of the brooks and rivers, and above all, any antique objects which may have been discovered by the inhabitants—sherds, terra cottas, vases, inscriptions, stones from buildings, etc.

All these appear to indicate that we have before us the site of an ancient settlement, which we make certain by an experimental research, a few trenches are drawn across the ground in question, and then we have a fair idea whether or not a systematic excavation would result in the hoped-for success.

When we now, after the more theoretical explanations, enter upon the actual work of the excavators themselves, we find that the preparations and practical work demand a much greater outlay of time and trouble than may appear at the first glance. Privations of all kinds await the excavator, though, indeed, there are not wanting incidents of the merriest and most amusing kind to keep up his spirits in lonely times.

Having chosen an excavating field, the next thing to be done is to obtain the consent of the government authorities in whose district the excavator intends to dig, and tedious diplomatic negotiations are sometimes necessary before everything is settled, and the digger's share of the finds definitely fixed. According to the laws of some countries, the finder has only the right of scientific exploitation, i. e., the right to photograph, and, perhaps, take casts of the objects discovered, and to publish the results. In other countries we are treated more favorably and receive, for instance, one-third, or if we are the owners of the ground, even two-thirds of the whole find.

The lands where one can work the whole year through are rare. It is partly the climate, and in no small measure the malarial fever from which our scholars in southern countries have to suffer so much, which calls a peremptory halt; partly, also, the local circumstances which necessitate the breaking off of the operations for some length of time, if only on account of the laborers, who are needed for the harvest and field work.

When the time comes for beginning the excavating campaign, you take leave of civilization for a length of time, and repair to the scene of future discoveries. Some foremen have been engaged and sent out in advance with the baggage. These overseers are mostly picked and experienced fellows, who, in many cases, have already taken part for years in excavations in the service of different nations. They acquire in the course of time a certain experience in archæological matters, understand perfectly how to manage the workmen, and know the habits and needs of the archæologists, so that they are everywhere indispensable.

Having reached the scene of operations, the first thing to be done is to find lodgings. There is very seldom a hotel in the neighborhood, or any place where tolerable quarters can be arranged. Should the researches be of presumably short duration, one simply puts up with what offers. Last summer, I, myself, lived for weeks in a hay-loft, slept on a wooden chest, and felt very well all the time. It is, of course, more comfortable to live in tents, especially when a number of scientists have to be accommodated. The chief tent, which is used both as office and dining-room, stands in the center; to the right and left of it are the sleeping tents, the tents for measuring instruments, photographic cameras, and valuable working tools and utensils. The less costly utensils, such as baskets, rollers, levers, and the like, lie outside, one of the foremen being responsible not only for their loss, but also for keeping them in order. Behind the main part of the camp lie the kitchen quarters. There is the kitchen itself, a magnificent structure, built of rough stones collected somewhere in the neighborhood, kept together with clay. The roof is made of rushes or straw, or whatever happens to be at hand, and if any one chance to have a spoilt photographic plate, it is put in for a window. A similar den is erected for the servants. Should the roof be a tarred one, and generosity have been shown in the matter of old photographic plates, such a hut will be the pride and boast of its inmate. "Have you ever slept in a castle?" was, for instance, the question put by the little serving-man to the cook, when they moved into their quarters on the occasion of some excavations by the Oriental Society in Egypt.

Near the kitchen are usually the zoological gardens of the expedition, which are divided into a domestic and scientific section. The domestic section contains the horses and donkeys, when they are needed, and poultry, ducks, geese, etc., in large numbers—before feast days, even a sheep. In the other more interesting division are to be found the various characteristic animals of the country, jackals, wild-cats, owls, and other creatures, many of which cut short their unwilling visit by finding out some means of leaving their improvised cages, which are frequently much too frail.

When the scene of excavations is remote from civilization, say in the far East, a guard room must be added, as constant post for the military escort.

But as the climate of the country does not permit of living in tents for the entire duration of the excavations, it is advisable from the very commencement to erect one's own excavation-house, more especially if there is a prospect of their occupying it a number of years. This building may be made so solid and firm that after completion of the excavations it can be kept up at a trifling expense and serve as quarters for visitors to the ruins.

At daybreak the work begins. The people, most of whom have already come a long way, are called over and place themselves with their hoes and baskets in rows of 10 or 15 by the side of the caller. When the column is complete, they march with their overseer at the head to the scene of operations, and the work is soon in full swing. When lorries are employed the boys are very busy filling the cars with baskets, which are handed to them by the man with the hoe. If there are no lorries the basket-carriers may be seen marching in long rows, carrying away the rubbish. One, sometimes two, men are constantly occupied in repairing the broken baskets, while boys have the task of supplying the men with drinking water. On hot days this is hard work; they are wanted everywhere, called everywhere, and have to drag about incredible quantities of the noble beverage in the course of the day. Of course, if the well or spring is some distance off, the carrying is done by a horse, the so-called "water horse," or a donkey, and the "water boys" have only to distribute the drink.

The men work very industriously as a rule, the overseers take care of that, now and then shouting a vigorous "Forward!" and when the whistle sounds for leaving off work, woe to the boy who dared to throw away his basket at the first sound of the whistle. The basket is first tidily emptied, then all are placed together and counted. Lazy and disobedient workers are punished by deductions from their wages, while good work is acknowledged by gratuities. Now and then it happens that some one asks leave for ten or twenty days. Either he wants to get provisions, for which he has to travel from three to five days, the same length of time being needed for bargaining, or he wants to get married, or to build himself a house. There are also some people who desire to rest on their laurels and fairly earned fortune, and who think when they have worked faithfully for a few months and earned a good sum they must retire on their riches, and with $20 or $30 in one's pocket one can live like a lord for some time in the Orient.

For the archæologist there is, as a rule, no want of variety in the work; now there is this and now there is that demanding the personal presence of the leader. Here comes an overseer rushing up, "Come, sir, and look at the boy; he is bleeding." Some slight injury has occurred, which generally passes over without any serious consequences, but occasionally also it may cause some little annoyance. Thus, for instance, one day immediately after dinner time, the head overseer came to me in the "working room," as my dwelling was officially called: "Come quickly, sir, they have all stopped work!" And truly the workmen were crowding by, making for their tents, and on the field of labor I found only a few left, who were able to explain the why and wherefore to me. The story went that a stone had struck one of them on the head with such force that he collapsed and lost much blood, and this being a bad omen, the work was immediately stopped. I began to fear that the men would not return to the work at all and we should be obliged to secure others in the more distant villages. But the patient recovered quickly, and the next morning at roll call not a man was missing except the patient himself, who sent a "cousin" as his substitute.

It is more pleasant when it is reported that a tomb, for example, has been struck. The case has to be carefully handled. The workmen receive a special gratuity for the find, but are then disbanded, and the select or elite troops are called in. These being a better paid group of old, trained, and trustworthy persons, are employed for especially difficult work and posts of trust. By these men the tomb is now laid bare and cleaned out. If the work cannot be accomplished in one day, a little tent is put up over night, in which two or three men have to keep watch. As an extra spur to their vigilance, an old blunderbuss is given over to them.

There is everywhere and always something to be done; besides, reports of the finds have to be written, wage lists, account books, etc., kept. Only Sunday, in Mohammedan districts Friday, brings some rest and leaves time for excursions, for shooting, or visits to the dignitaries of the surrounding villages. On holi-

days the whole village comes to pay a return visit. Coffee and cigarettes are handed around, and the whole company, the chieftain of the village, the magistrate, the night watchman, etc., squat on the ground and declare solemnly that all the people in the village are good, that thieves are to be found only in the neighboring village, and that they are especially attached to the Americans or Germans as the case may be.

The field of excavations displays quite a different picture when the end of the campaign approaches. Everywhere there is thumping and hammering going on, big chests are being made for the finds, the tents are taken down, and the buildings bolted and barred; tools are packed up or stowed away in the buildings, the draft oxen are being brought up to carry away the big chests on drags or carts, camels and donkeys are being loaded, everywhere the liveliest activity prevails. After a little all have withdrawn, the workmen have gone back to their villages, the archæologists to civilized life, calm and forsaken lies the field, recently so full of life, only high up in the air big brown eagles are gyrating in wide circles, ready to pounce upon the creatures which are slinking about the exhumed ruins to settle there.

THE RETURN OF HALLEY'S COMET.

AN EVENT OF ASTRONOMICAL INTEREST.

BY S. I. BAILEY.

An event of extreme interest, not only to astronomers, but to the world at large, will soon take place. This is the return of the periodic comet made famous by the genius of Halley.

Before Halley's time comets had been regarded as chance visitors to our solar system, except when they were looked upon as special messengers of divine wrath. Newton, however, showed that comets were subject to the law of gravitation. By mapping the paths of many comets, Halley found that three of them apparently had the same orbit, that is, they were different apparitions of the same object. He observed this comet in 1682 and predicted its return again after 76 years. He knew that he could not live to witness the event, and his words concerning it are rightly famous: "If it should return according to our predictions, about the year 1758, impartial posterity will not refuse to acknowledge that this was first discovered by an Englishman." It returned in March, 1759, a few months later than Halley expected, and only seventeen years after his death. Pontécoulant was one of at least five mathematicians who computed the last return of Halley's comet in 1835. It reached perihelion within a few days of the predicted time. Pontécoulant also made the necessary computations for the next return, and published his results in 1864. His date for perihelion is May 24, 1910. It was to be expected that before the time for its return various astronomers would be sufficiently interested in the problem to redetermine the elements. So far this appears to have been undertaken only by the English astronomers, Cowell and Crommelin. It is interesting to know that the results which they obtain are in substantial agreement with those of Pontécoulant, so that the comet may be confidently expected to reach perihelion passage in May, 1910. Astronomers will not wait till that time, however, for their first view of the comet. Prof. O. C. Wendell has published in Popular Astronomy an ephemeris based on the elements of Pontécoulant. From this it appears that at the present time the comet is less distant from the sun than Saturn. Its position, in the northern edge of the constellation Orion, is favorable for observation, but it is doubtful if even the great telescopes of the present day can reach it at present. Owing to the form of its orbit and its distance, the comet is moving in nearly a direct line toward the sun, and as viewed from that luminary would appear to stand nearly stationary in the sky. Owing to the motion of the earth, however, it will sway, during the next year and a half, backward and forward on the borders of Orion, Monoceros, Gemini, and Taurus. About the first of October, 1909, its apparent motion will become very rapid as it approaches the sun. After April of the present year it will be unfavorably placed for several months. Next year the conditions will be somewhat similar, except that by January, 1909, the distance of the comet from the earth will be only that of the orbit of Jupiter. By October, 1909, the distance will have decreased to about 300 millions of miles, and by that time the comet will probably have been "picked up" photographically or visually.

The mean period of Halley's comet is 76 or 77 years, but, owing to the powerful perturbations of the great planets, this period varies much. Cowell and Crommelin state that the revolution of 1222 to 1301 was the longest on record, taking 79 years and 2 months, while the present round is the shortest, only 74 years and 5.5 months. It is believed that apparitions of this comet have been recorded during the last 2,000 years, but the identity of the earliest appearances has not yet been certainly established.—Science.

HUMIDORS FOR ROOMS.

A DESCRIPTION OF AIR MOISTENERS

BY DR. FRANZ SCHACHT.

The quantity of water vapor that can be taken up by a given volume of air increases with the temperature. The air contains much more moisture in summer than in winter. In summer the air of rooms differs little from the air outdoors either in temperature or in humidity, but in winter heated rooms have an artificial atmosphere which is very much drier, as well as warmer, than the outer air. When air contains all the moisture it can take up at its temperature it is said to be saturated. When it is not saturated it absorbs moisture from any exposed surface of water, or, more correctly, some water evaporates and mingles with the air. This evaporation takes place at all moist surfaces, including the human lungs and skin, at a rate proportional to the dryness of the air. This continual desiccation is injurious to health and destructive to furniture and wall paper. The important factor is not the absolute humidity, or the whole quantity of moisture in a cubic foot of air, but the relative humidity, or the ratio between the amount of water vapor actually present and the whole amount that the air can contain at the actual temperature. The heated air of a room often contains more moisture than the cold outer air, but its relative humidity is lessened because its capacity for moisture is greatly increased by heating.

Excessive dryness of the air is more objectionable in a poorly-ventilated than it is in a well-ventilated room, because two defects are worse than one. Hence, some method of moistening the air is particularly necessary in rooms heated by steam or hot water. With steam heat the moistening may be effected, though not very conveniently, by allowing a little steam to escape into the room, but with hot-water heat some special device is required. The same necessity exists in rooms heated by a hot-air furnace, for, although the furnace supplies a continual stream of fresh—if not always pure—air, which has already taken up some water vapor from the evaporating pan of the furnace, the quantity of moisture thus added is usually very inadequate. And even in a room heated by a stove, which creates an indraft of fresh air through every crevice, a device for supplying moisture is very desirable.

There is an economical as well as a hygienic disadvantage in very dry air, for the rapid evaporation from the skin exerts so powerful a cooling action on the body that a higher temperature, and consequently a greater consumption of fuel, are required.

Humidors, or devices for moistening the air, are constructed on the principle of exposing to the air, within convenient limits of space, as large a wet surface as possible. The evaporation is greatly facilitated by placing the evaporating surfaces in a vertical position so that they are exposed to a current of air which is impelled upward by the heat of the stove or radiator. A horizontal surface, like the surface of water in a simple evaporating pan, remains in contact with a more or less stagnant stratum of air and the evaporation is correspondingly retarded.

Four of the five systems with which the writer is acquainted employ vertical surfaces which are kept wet by ascending and descending streams of water. These five systems are: 1, The Büssing Automatic Humidor; 2, the "Humidophor"; 3, the "Draka"; 4, the Automatic Humidor "Sanitas"; 5, the "Atmefrisch."

The automatic character of Nos. 1 and 4 consists in the alternate ascent and descent of the water. Each of these devices has an upper and a lower water vessel and a cloth stretched vertically between them, while each of the other three devices has only a single vessel of water, into which the porous evaporating body dips and raises water by capillary action. The Büssing humidor is truly automatic because when the lower vessel becomes filled its weight draws the cloth out of contact with the water in the main reservoir above. Thus the overflowing of the lower vessel is prevented automatically. The Sanitas humidor, on the contrary, is automatic only to the extent that the cloth keeps wet by drawing up water from the lower vessel after it has emptied the upper vessel by siphoning. In this apparatus there is danger of overflowing the lower vessel if the upper vessel is refilled, except when the lower one is nearly empty. The Büssing humidor, the oldest of the five, is also the best, and is therefore placed first in the list, which is arranged in order of merit. All humidors should be placed on the radiators, registers, or stoves, or as near them as possible, where the temperature is highest and the circulation of air most active. The Büssing humidor is peculiarly well adapted to use with a steam radiator, for the main reservoir may be set on the radiator and the cloths draped on each side of it, the width of the cloths being made equal to that of the radiator. Each cloth is weighted at the bottom with a lead pipe, which also serves to collect the water that escapes evaporation as it trickles down the cloth. When the pipe becomes nearly full its increased weight causes the roller to which the upper end of the cloth is attached to turn far enough to lift that end out of the water in the upper vessel. The water for evaporation is then drawn from the lead pipe until the weight of the latter is diminished sufficiently to allow it to rise and re-establish contact between the cloth and the water of the reservoir above. The apparatus is also made with a single cloth and pipe for use as a fire screen or for hanging on the wall, near and above a stove.

In the apparatus called Humidophor many narrow strips of blotting paper or asbestos felt are suspended vertically with their lower ends dipping in water. Alternating with the strips are openings in the bottom of the water vessel, to which are fitted tubes rising above the water level. By this means ascending currents of warm air are brought into contact with each side of each strip, so that a large effective evaporating surface can be secured with a small and compact apparatus. It is advisable to add an automatic regulator by means of which the pan is supplied continuously with water from a large vessel or the service pipes. If this is not done the pan should be large enough to give an abundant supply of moisture through the night.

The Draka is similar in principle to the Humidophor, but it has no air tubes and the sheets of paper are broader, fan-shaped, and project obliquely over the rim of the water pan in order to insure intimate contact with the ascending current of warm air.

The Sanitas apparatus has two water pans. A dozen or more wire frames, covered with cloth, rise from the lower pan and their curved tops dip into the upper pan. The cloths are kept wet partly by capillary action and partly by siphoning. As most of the wet sur-

face is shielded from the ascending air current by the lower pan, the apparatus is less efficient than those described above.

The Atmefrisch is still less efficient, but it possesses the merit of simplicity. It consists of a shallow pan filled with a porous slag produced at the Krupp Iron Works. The evaporation is most rapid when the pan contains very little water, because the extensive vertical and inclined wet surfaces of the fibrous mass add their effect to that of the horizontal surface of the water. Even in this most favorable case, however, the free access of air currents is prevented by the pan and the grating over it. Furthermore, as so small a quantity of water would be exhausted in a few hours, it is necessary at night to fill the pan to the brim, in which condition it acts like a simple evaporating pan, as the slag is covered by water.

In selecting humidors it should be remembered that the smallest sizes are inadequate for any but the smallest of rooms. In general, humidors of large size and efficient type should be chosen, for there is little or no danger of making the air too damp by the use of such devices.—Adapted from Prometheus.

ELECTRICAL NOTES.

Chromium prepared in an electric furnace was found by Moissan to be slightly soluble in molten copper, and investigations of this fact led to the discovery of a new form of chromium, described in the Revue d'Electrochimie. This new form is crystalline, has a density of 7.1, and is chemically active; it burns with a bright flame when heated alone in the air and is attacked even by nitrogen at a red heat.

A curious instance of interference by a rat with the electric lighting of a town was recently given in a report from Berlin. The town of Charlottenburg was suddenly plunged into darkness at an advanced hour on Tuesday evening, February 18, by a failure of the electric current. The stoppage, which lasted half an hour, was caused by a rat which had jumped in among the 'bus bars at the power station. It is the second occasion on which Charlottenburg has been deprived of light by such a cause.

Experiments have been carried on for several years at the Oerlikon Machine Works, in Switzerland, with electrical trains for the purpose of ascertaining the best methods of electrically operating main line railroads with heavy traffic. The experiments are now closed, and, according to the Railroad Gazette, the system adopted is single-phase alternating current of 15,000 volts, with 15 periods per second, using overhead conductors. The experiments are said to have determined that there is no danger in employing high voltage, *provided proper precautions are taken*. Our contemporary Machinery asks: "What are they?"

The electrolytic process for preparing indigo was the subject of a paper read by M. Chaumat, a prominent engineer of Paris, before the Electrical Society. The paper is of considerable length, and deals with the details of the electrolytic method which the a[illegible]r claims to be superior to the others which are now in use in indigo manufacture. Germany alone exports an annual amount of this product which is valued at no less than $22,000,000. In France, the basis of treatment may be estimated as 500 to 600 tons of indigo per annum. The electric process is found to require but a comparatively small amount of current, seeing that for the above amount of product the corresponding consumption of current would be only five million kilowatt-hours. We expect to give a detailed account of the electrolytic indigo process, which presents some features of considerable interest both from a technical and a commercial standpoint.

In an article in L'Electricien, a system of winding magnet coils, using bare wire, is described, a subject which has already been discussed at length in the Scientific American Supplement by A. Frederick Collins. The reason for the possibility of using bare wire in winding is that when two adjacent turns of the wire come in contact, they only make a line contact, and the resistance of this contact will be so great compared with the resistance of one turn of wire, that the current will flow through the wire rather than across the contact. If then the coil consists of but one single layer of wire, it is not necessary to insulate this wire, as the resistance of the contact will be sufficient to prevent short circuit. Of course, this does not apply to the second layer of wire, since the latter will come in contact with the layer below, and the resistance of the contact will be small compared with the total resistance of the intervening turns of wire. Consecutive layers, of course, have to be insulated from one another. The system is evidently limited by the diameter of the coil of the wire. If the diameter of the coil is large, and the wire is small, the current may pass across from turn to turn easier than by passing around the coil. Therefore the system is suitable for large coils only in cases when these are wound with fairly large wire. It is claimed that magnet coils wound in this way have proved satisfactory.

ENGINEERING NOTES.

We have stated that the German Society of Engineers had discontinued the work on its Technolexikon, on account of the high cost. It is stated in the Times Engineering Supplement that the society has appealed to the Prussian government for assistance in finishing the work, and it will depend upon the decision of the Minister of Education whether the work will proceed or not.

At a meeting of the Institution of Mechanical Engineers of Great Britain, one of the speakers mentioned that the manager of an automobile factory had stated to him that by using distilled water as a cooling medium and cutting lubricant, in place of ordinary water, he had been able to increase the life of the milling cutters, used in the factory, from five to ten times. Condensed steam from the steam engine would serve the same purpose as distilled water.—Machinery.

The Minister of Public Works and a committee of American engineers attended the ceremonies on March 15 of opening the Chilian section of the transandine tunnel, in connection with the railway from Arica, Chili, to La Paz, Bolivia. The tunnel will be the highest in the world. The transandine railway project was approved by the Chilian Congress in 1903, and the first section of the railway was opened in February, 1906. This section reaches from Arica to the foot of the Andes, where the tunnel begins. The line when completed will shorten the time to Buenos Ayres by six hours.

According to the Engineering and Mining Journal, tungsten in ore can be tested for in the field by the following method: Pan the crushed ore so as to separate the heavy minerals from the gangue. Then boil the concentrate in hydrochloric acid for 20 to 30 minutes in a glass vessel, for instance a beaker. About five minutes before the end of the boiling add nitric acid, using one-quarter the volume of the hydrochloric acid. A canary yellow precipitate of tungsten trioxide will be formed, if tungsten is present, and this will adhere somewhat to the vessel. If this precipitate is soluble in ammonia, there is no doubt of its having been formed by tungsten.

As a result of a two years' trial of a four-cylinder, balanced, simple locomotive, on the London and South Western Railway of England, says the Railway and Engineering Review, a number of ten-wheel locomotives of this type have been designed and built by the railway, and put into service as a standard for heavy passenger service. The boilers of these locomotives have a tube heating surface of 2,210 square feet, a fire-box heating surface of 160 square feet, and 357 square feet of additional fire-box heating surface, secured from cross water-tubes. The grate area is 31.5 square feet. No injectors are used, these being replaced by two duplex feed-pumps, and the feed-water is heated by the exhaust steam from the pumps. All the cylinders are 16½ x 26 inches, the exterior being coupled to the middle drivers, and the interior to the forward drivers. The exterior valve motion is Walschaerts', and the interior, Stephenson's, both handled together by a steam-hydraulic device. All the cylinders exhaust through one pipe. The drivers are 72 inches in diameter, and the engines weigh 52 tons on the drivers, and 75 tons complete.

The more modern staiths for shipping coal at North Blyth have shown a defect which the use of electric power has done much to remedy. The staiths are very high and coal has a long way to drop into the holds at low tide, with the result that much coal is broken, and its value is diminished thereby. The anti-coal-breaker arrangement consists essentially of a system of buckets balanced to run over the suspended shaft, the whole being suspended from the jib of an electric crane fixed on the upper part of the staith. Coal from the ordinary spout is run into the buckets on one side of the chain, and these are carried by gravity into the hold of the vessel, where they are emptied and the buckets begin the return movement. The jib crane used is capable of carrying 8½ tons, and the lifting and slewing motors are 20 and 8 brake horse-power respectively. The lifting speed is 25 feet per minute. The speed of the bucket chain is capable of being regulated by an automatic centrifugal brake to a velocity of 120 feet per minute. In cases where the ground-level of a wharf is low, coal hoists are used to a great extent and also coaling jib cranes. With regard to dock coal hoists this is a field in which hydraulic machinery has hitherto been universally adopted. The wagons are raised by a hoist and tipped by means of another ram attached to the platform, the wagons being fitted with end doors; the wagon is then lowered again and the platform lowered to a high-level empty wagon road, where the wagon is run off and the platform lowered to the ground-level for another full wagon. Electrically driven coal hoists, which perform exactly the same operations, have recently been erected at Rothesay Dock, Clydebank, by the Clyde Navigation Trustees. In some cases coaling cranes are displacing hoists, or are being provided as additions.

TRADE NOTES AND FORMULÆ.

Cement for Sealing Bottles.—Rosin, 3 parts, 1 part of caustic soda, 5 parts of water, mixed with half the weight of calcined plaster, and well incorporated together.

Removal of Spots.—To take spots caused by wine vinegar, must, sour wine, etc., out of white goods, wash out with pure water to which ammonia has been added. Colored cotton and woolen fabrics, silk, satin, etc.: The spot must be moistened with dilute ammonia and the fabric afterward thoroughly washed in water. Acid spots: If fresh they can be readily neutralized with ammonia, old spots cannot. Vegetable, fruit, dye stuff, red-wine, cherry, egriot cherry, elderberry, strawberry spots, etc., white goods: Either remove the spot by rinsing in javelle water, or in dilute chlorine water, or by holding over burning sulphur, the fabric to be later washed out in water. Dyed cotton and wool fabrics: Wash out in hot soap-water and a little chlorine water, rinse in water to which a little ammonia has been added, then dip in hyposulphite of soda solution, moistened with a tartaric acid solution and thoroughly rinse out in hot water. Silk, satin, etc.: The same, but solutions greatly diluted.

Grass spots: White goods, boiling water; colored cotton and woolen fabrics, silk, satin, etc., chloride of tin solution, moisten and wash in water.

Tannin or green nut spots, etc.: White goods, diluted javelle water, or diluted chlorine water. Dyed cotton and woolen goods, silk and satin; wet the spot, treat with chlorine water (diluted if required), pure river water.

Coffee and chocolate spots: Treat with mixture of white of egg and glycerin, warm water and iron hot, while still damp, on the wrong side.

Aniline ink spots: White goods, alcohol with some acetic acid. Dyed cotton goods, woolen fabrics, silk, satin, etc., alcohol.

Gall nut, alizarine ink and nut spots: White goods, hot concentrated tartaric acid solution, cold river water. Dyed cotton and woolen goods: Let fall on the spot a drop from a burning tallow candle. Wash it out in concentrated phosphate of soda solution, then in water. (In the case of fast dyed goods use tartaric acid or chloride of lime.) Silk, satin, etc.: If dyed fast, strong vinegar, for a time, water and wood ashes, strong soap-water.

Old gall nut, alizarine ink, or rust spots, dilute chloride of tin solution, warm river water.

Sesquichloride of iron spots, white goods, colored cotton and woolen fabrics: Yellow prussiate of potash, to which sulphuric acid has been added; carbonate of potash solution, ultimately also dilute sulphuric acid. Silk, satin, etc., the above named solutions, very much diluted.

Silver-salt spots: White goods, colored, cotton goods, woolen fabrics, neutral chloride of copper solution. Dab with a crystal of hyposulphite of soda dipped in ammonia; then moisten with a permanganate of potash solution, finally dip in a bisulphate of potash solution. Silk, satin, etc., the same, but carefully.

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